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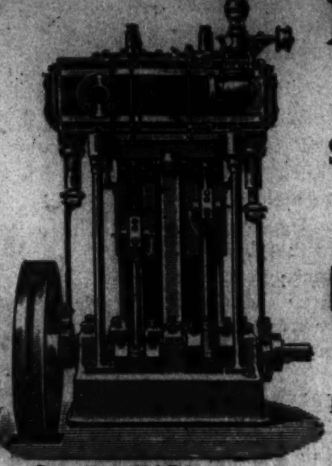

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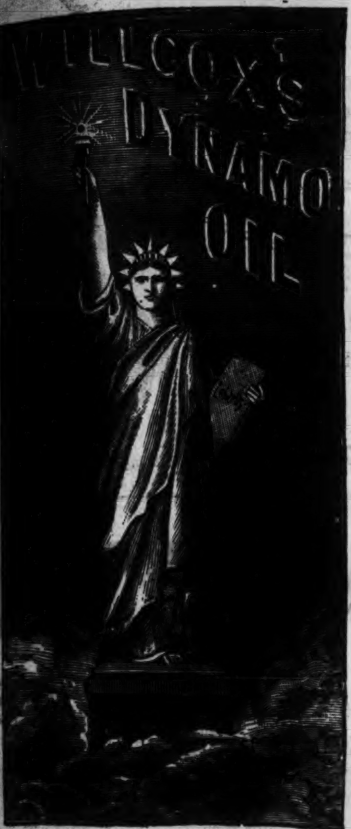

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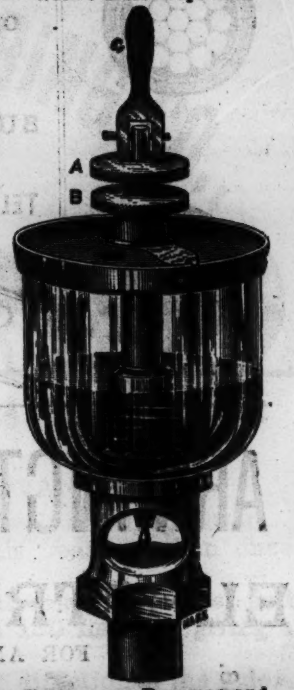

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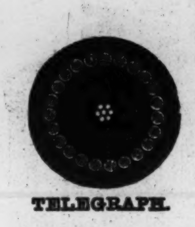

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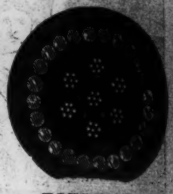

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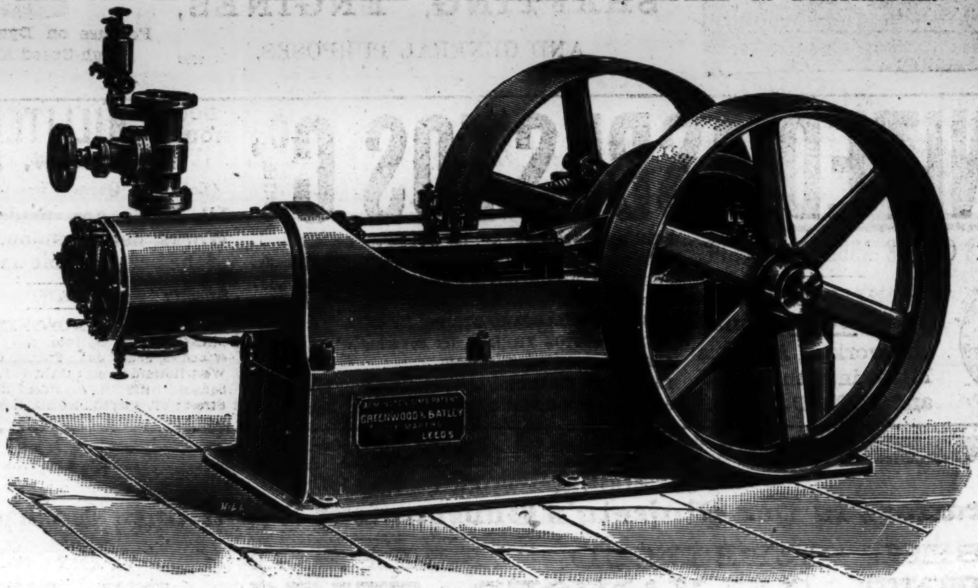

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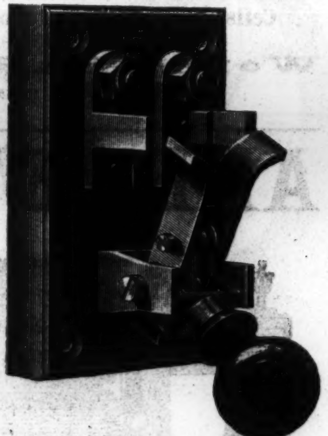

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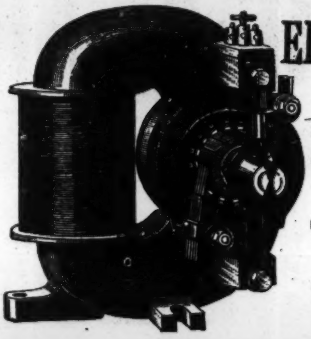

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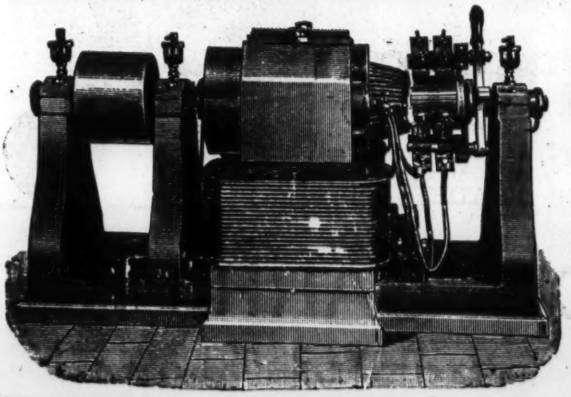

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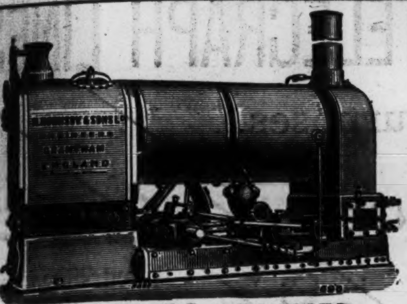

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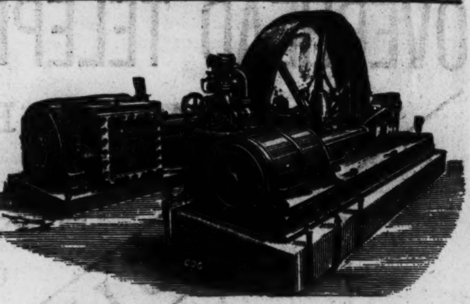

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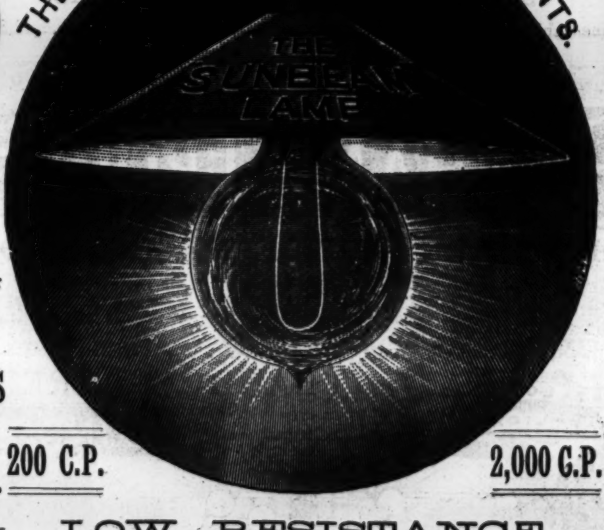

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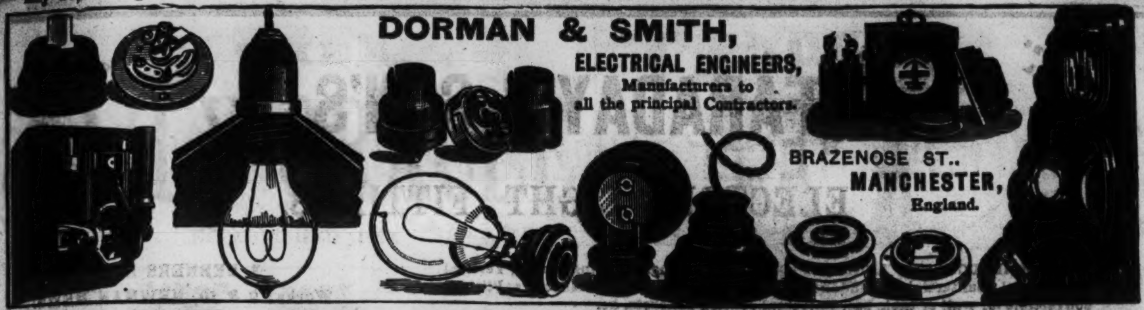
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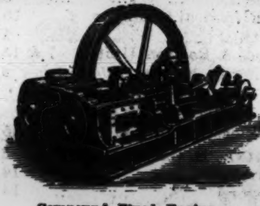

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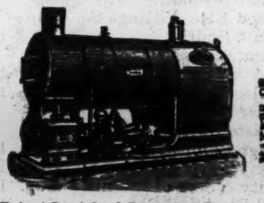

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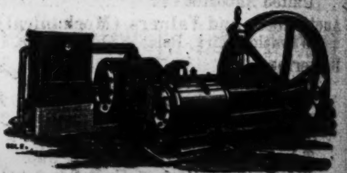

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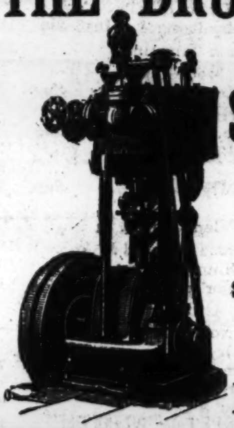

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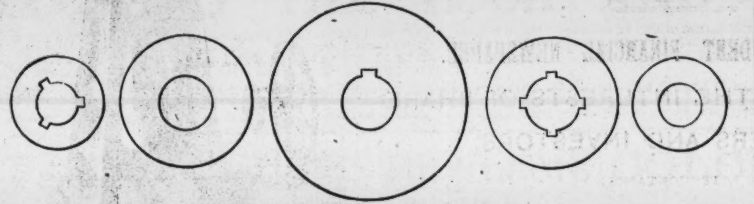

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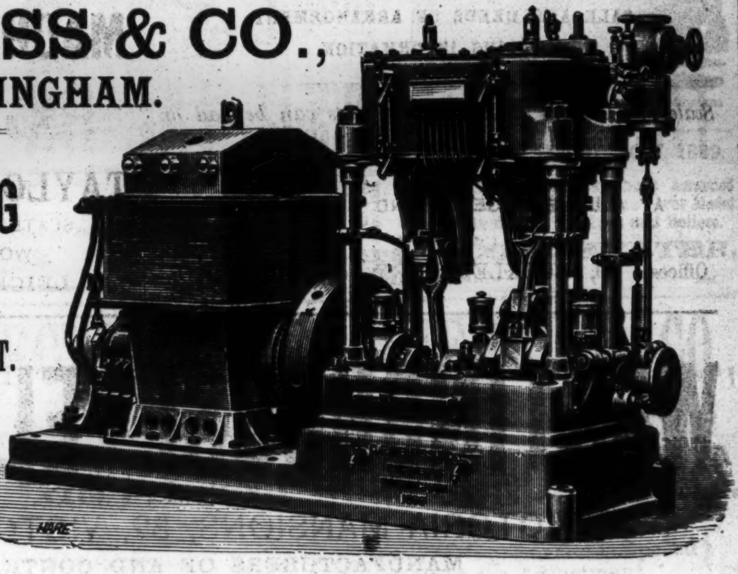

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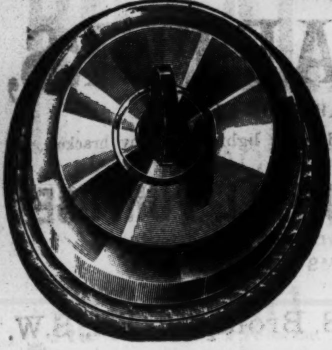

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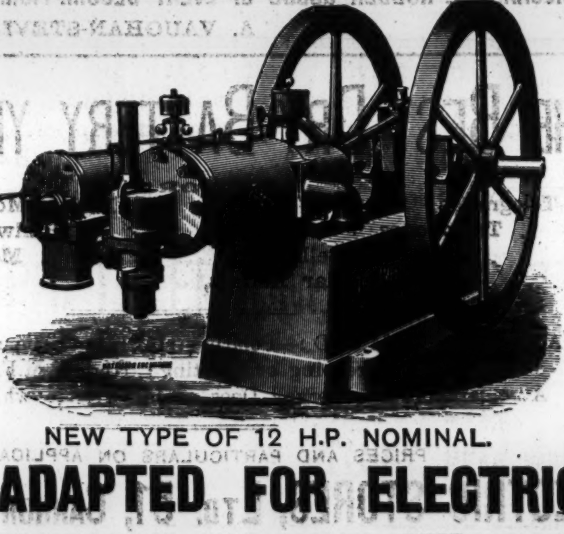

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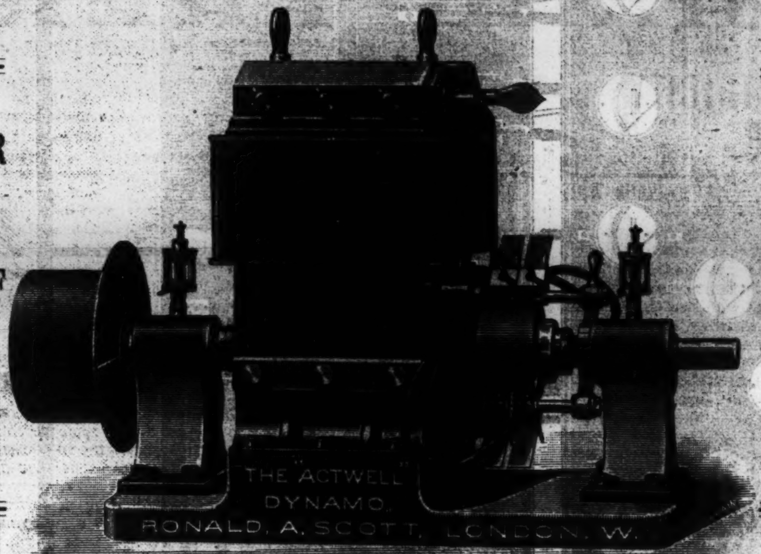
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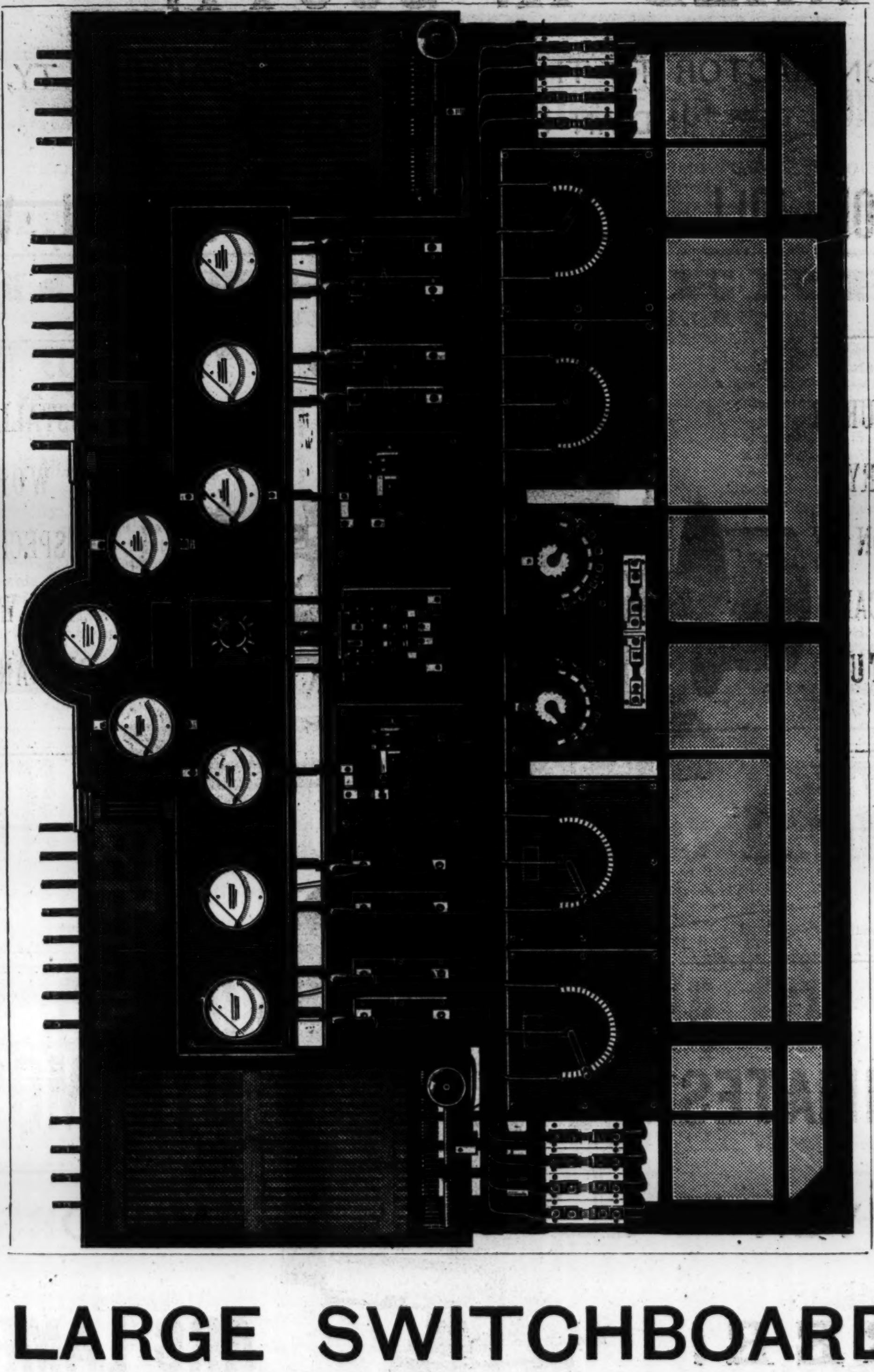

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IT is said that "imitation is the sincerest flattery," but, whether that be so or not, we notice with no small amount of satisfaction that *something* during the last few weeks has caused certain of our "friends" to follow, as nearly as possible consistent with decency, this illustrated system of advertising. With that diplomacy, however, which is chiefly characteristic of the well known bird noted for a big body and a small head, they have chosen for this purpose, not the columns of the ELECTRICAL REVIEW, but the columns, if you please, of one of your contemporaries! But we do not complain; we rather rejoice in the fact that "we alone have done it!" We merely invite your readers to watch the fitful changes to which we respectfully draw attention in the hope that it may afford them as much pleasure as it has ourselves.

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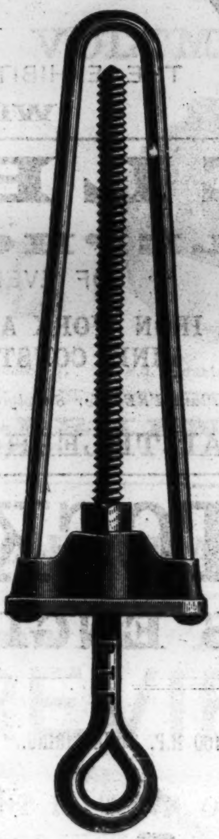

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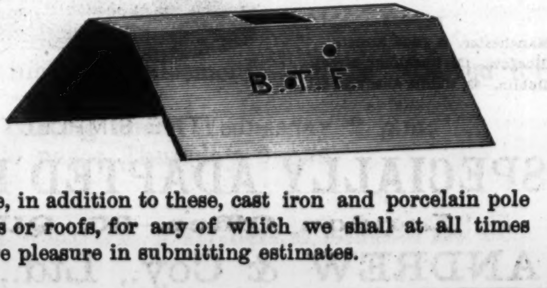

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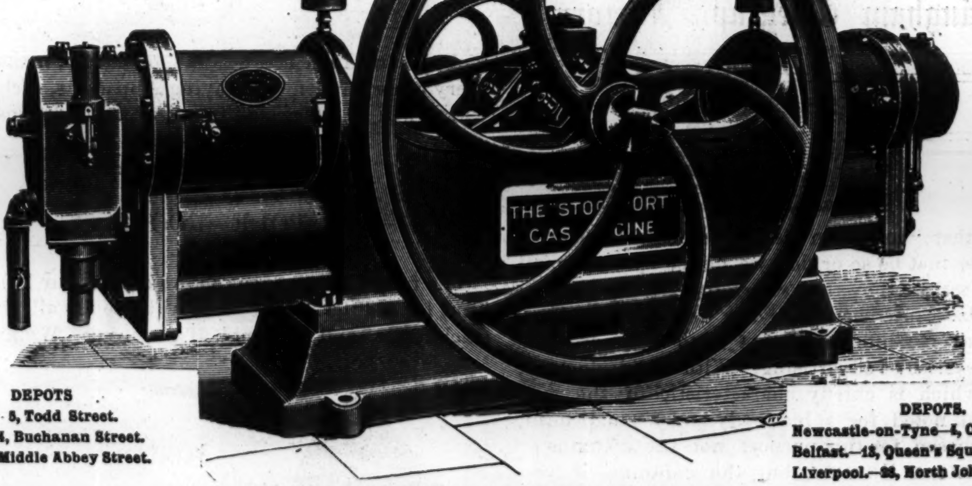

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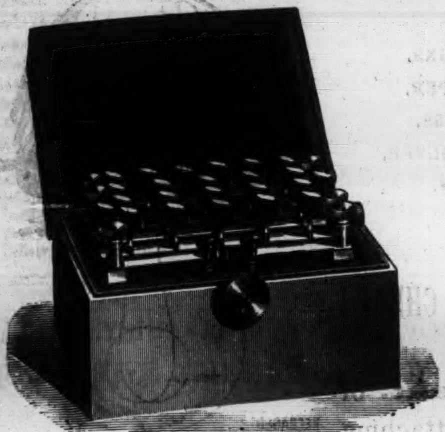

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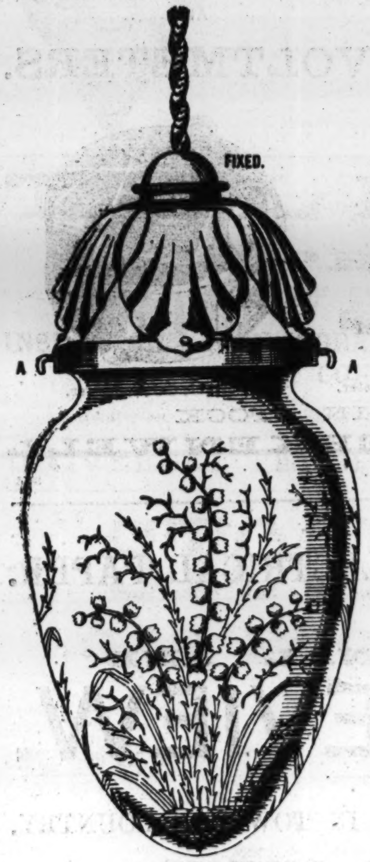

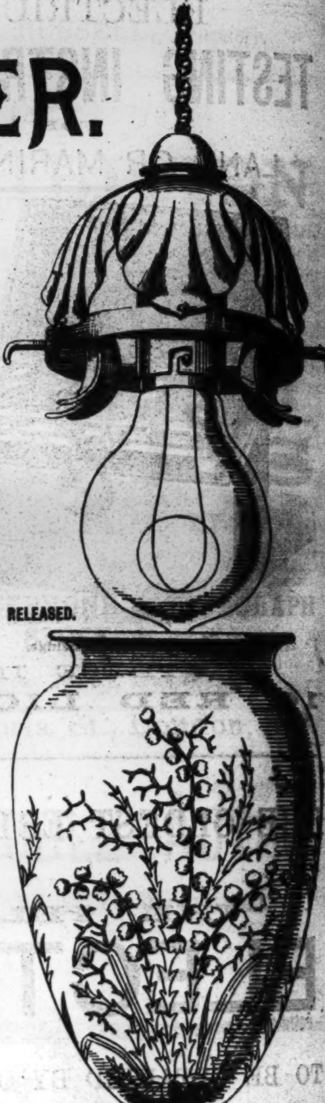

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VOL. XXVIII. MAY 22, 1891. No. 704

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ELECTROLYSIS: ITS APPLICATION TO QUALITATIVE CHEMICAL ANALYSIS.

A PAPER on the above subject was read at Liverpool a short time ago by Dr. Charles A. Kohn, B.Sc., Assistant Lecturer in Chemistry at University College. This paper dealt with a systematic examination into some electrolytic methods of chemical analysis which has been recently carried out by Dr. Kohn, in conjunction with Mr. E. V. Ellis, B.Sc.

The first application of electrolysis to chemical analysis was made in 1850 by Gaultier de Claubry, who employed an electric current for the detection of metals when in solution. Other investigators followed in the same line of research, and in 1861 the late Prof. Bloxam published two papers on the application of electrolysis to the detection of poisonous metals in mixtures containing organic matters; such mixtures, in fact, as might be taken from the stomach and intestines, &c., of a deceased person who had died from metallic poisoning. These papers were published in the Journal of the Chemical Society, vol. xiii., pp. 12 and 338. They contain a description of means for detecting small quantities of arsenic and of antimony by subjecting their acidulated solutions to electrolytic decomposition. The arsenic was evolved as the hydride, and then recognised by the usual chemical reactions, whilst the antimony was mainly deposited in the form of the metal upon the cathode.

The electrolytic method for the detection of arsenic, in which there is now no fear of contamination from impure zinc (which frequently contains traces of arsenic), has since been elaborated by Wolff, who has developed the process to such a degree of delicacy, that he has succeeded in detecting as little as 0·00001 gramme of arsenious oxide by this means.

The voltaic current is made use of also in ordinary qualitative analysis for the detection of tin, antimony, silver, lead, arsenic, &c., by employing a more electro-positive metal to precipitate a less electro-positive one from its solution.

In 1889, Dr. Kohn devised several quantitative electrolytic methods of analysis which have also placed in the hands of chemists means both elegant and accurate for determining and separating metals qualitatively. These methods are especially useful in cases of medical and medico-legal enquiry. They are not supposed to supersede in any way the ordinary methods of qualitative analysis, but are intended to serve as final and crucial means of identification, and thus to render it possible to detect very small quantities of the substances in question with very great certainty. As such, they fulfil the required conditions admirably, being readily carried out, comparatively free from contamination with impure reagents, and capable of being rendered quantitative when desired.

It will scarcely be within our province to describe the details of these electrolytic methods in their application to the detection of mineral poisons like antimony, mercury, lead and copper, and to the detection of gold and silver. We will, however, quote the leading features of the process as applied to mercury.

The mercury must first be extracted with nitric acid. It is then separated from this solution on a small closely wound spiral of platinum wire, the latter being immersed in the liquid, and a current capable of yielding from four to five cubic centimetres of electrolytic gas per minute being employed. Half an hour is sufficient for the complete deposition of the mercury; the latter is removed from the spiral by heating in a test-tube, when the mercury forms in characteristic globules on the upper portion of the tube.

The spiral of platinum wire is an essential feature in the methods as applied to the detection of gold, silver, copper, lead and antimony.

In cases of poisoning, the organic matter with which these metals are associated must first be destroyed in the usual way by means of hydrochloric acid and potassium chlorate, and the precipitate obtained in the ordinary course of analysis then subjected at suitable stages to electrolysis. But urine can be tested directly for these poisons.

It will be noticed that a chemical process necessarily precedes the electrolysis. Dr. Kohn appears to be of opinion that it would be a very difficult matter to effect the separation of the mineral poisons from organic matter electrolytically without previous removal of the latter. The oxidation of the organic matter by the electric current is a slow process, and is not likely to be more complete or more effective than the means usually adopted.

In the discussion which followed the reading of the paper, however, Prof. Campbell Brown said he had no doubt that if the subject were pursued farther a method would be devised some day, by means of which arsenic and other mineral poisons could be detected directly by electrolysis without any previous separation of the metal from organic matter; it was a great *desideratum* to have a method for detecting arsenic and separating it from the contents of the stomach directly without previous destruction of organic matter.

In the course of some other remarks which were made upon the paper read by Dr. Kohn, it is interesting to observe that Dr. Huster said he was about to construct a new laboratory, and that one of its new arrangements would be the installation of electricity, by which researches similar to those described could be conveniently carried out.

THE FRENCH TRANSATLANTIC CABLE.

THE Council of State has recently given judgment in the suit between the Anglo-American Telegraph Company and the Compagnie Française du Télégraphe de Paris à New York, and has pronounced in favour of the first-mentioned company.

The different phases through which the dispute between these companies has passed may be summarised as follows:

The Anglo-American Telegraph Company obtained, on July 6th, 1868, a concession from the French Government for a cable between Brest and Newfoundland. On the 7th January, 1879, a concession for a transatlantic cable was granted by the French Government to M. Pouyer-Quertier, who transferred it to the Compagnie Française du Télégraphe de Paris à New York.

From the commencement a war of rates was waged between the above-named companies, and it was terminated on the 24th September, 1880, by means of a friendly arrangement. By this agreement, entered into by the French company, owner of one cable, the English company, owner of four cables, and the Direct United States Company, owner of one cable, the several parties bound themselves to adopt a uniform tariff, to lend to one another their cables in case of an interruption, and to make a common purse of the receipts, the division being 16 per cent. for the French company, and 84 per cent. between the other two.

On the 31st December, 1886, the French company notified its English partners that their agreement must be cancelled, and that the community of interests must come to an end. On the protest of the English companies, the French company advanced the plea of *force majeure*, citing a letter from the Minister of Posts and Telegraphs, dated 30th December 1886, which pointed out that the fusion of its interests with those of the English companies was in contravention of the clauses of the contract of 7th January, 1879.

The English company then brought the matter before the Tribunal of Commerce of the Seine, which, by a decision of the 2nd January, 1888, ordered the French Company to resume its agreement with the English company, and condemned it to pay to that company 2,000 francs per day for every day from the 31st December, 1886, up to the date of the resumption of the agreement.

The French company lodged an appeal before the Civil Court of Paris, which, before delivering judgment, it found necessary, by a decision of 24th April, 1888, to refer to the administrative authority for the interpretation of those clauses of the Ministerial letter of the 30th December, 1886, which directly applied to the obligations imposed on the French company by its concession.

The administrative authority submitted the question to the Council of the Prefecture of the Seine which, by decree of the 19th March, 1889, decided that the Ministerial communication of the 30th December, 1886, correctly interpreted the concession as being infringed by any agreement such as was entered into between the French and English companies, and that further, the said letter compelled the French company to break its agreement with the other companies.

This decision was assailed by the Anglo-American Telegraph Company before the Council of State, which pronounced in favour of the English company, annulling the judgment of the Council of the Prefecture, and pronouncing that the Ministerial communication of the 30th December, 1886, did not in itself constitute an authority for the breaking of the agreement between the companies, nor had the French company been prevented from obtaining the consent of the Government to such agreement, in the method provided for by the conditions of the contract. In consequence of this decision a heavy fall has occurred in the Pouyer-Quertier cable shares.

The Jablochkoff Electric Lighting Patent.

THE petitions of the Electrical Engineering Corporation, Limited, for the confirmation and extension of Jablochkoff's patent (electric light), dated May 22nd, 1877, were last week dismissed, scarcely, we imagine, to anybody's surprise. It is not necessary to indulge in any lengthy comments upon this matter for we entered fully into the subject and the probable issue in the REVIEW for January 16th, and the result completely bears out the views we then expressed. Both petitions were quashed on purely technical grounds, and we cannot help thinking, from a perusal of Lord Watson's judgment, that the case for the owners of the patent was bad throughout, and that they should have been so instructed by their legal advisers. Moreover, it appears that the proceedings connected with the application for an extension were completely out of order, that is, if we may accept the decision of Lord Watson, for as regarded that application the petitioners were in this dilemma: If it be represented as a petition presented under the terms of the recent Act the answer was conclusive that the statute had not been complied with, because it was not presented more than six months before the natural currency of the patent came to a close. The other alternative was that it was an application under the old law, and if it was viewed in that aspect the provisions of section 25 of the Patent Act, 1852, were as fatal to the power of this board to deal with the matter of extension as those provisions were fatal in the other case of an application for confirmation. Surely the technical and legal advisers of the Electrical Engineering Corporation should have known the limit of time for presenting their petition? However, "All's well that ends well," and probably but few will regret that the transformer *per se* is freed from monopoly.

REMARKS ON INDUCTION IN MULTIPLE CORE CABLES.

By P. CHR. DRESING and K. GULSTAD, of the Great Northern Telegraph Company.

(*Concluded from page* 590.)

WE cannot help thinking that the manner in which the cores in multiple core cables are laid together with only some threads of jute yarn in between them, so as to form a more or less cylindrical body, is somewhat favourable to the production of mutual induction between the cores. A cross section of any two or three-core submarine cable will show how closely the cores are pressed together, and any practical man, who has had to do with these cables, will corroborate the fact that when they are opened out the cores are generally found to be more or less flat in certain parts, where the surfaces have been squeezed together. Now, we think there is not much doubt that the induction between such cores is somewhat greater than it otherwise would be, for the simple reason that wherever the surfaces are pressed so hard together as to leave flat marks, the possibility of a film of water between them is excluded, the screening effect of the water is thus diminished (we have seen that at the best it is but an imperfect screen), and the electrostatic induction from core to core augmented.

The cross section of a double core cable is shown in fig. 8,

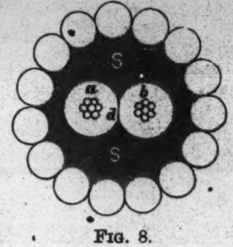

FIG. 8.

and it is easily seen from the following experiment that a direct charge must take place between the cores.

Referring to the same figure, *a* is an insulated conductor, *b* another conductor consisting of a strip of tin foil, that by means of a wire is connected to the metallic screen, S, representing the water round the cores. Whenever *a* and S are connected respectively with the positive and negative pole of an influence machine, the strip, *b*, will be deflected towards *a*, indicating a charge between them. The deflection is more or less violent, according as the space, *d*, is large or small, and it will not totally cease unless *d* becomes rather small.

It is not impossible that this peculiar feature in the construction of multiple core cables, as mentioned above, plays a rather important part in causing electrostatic induction between the cores, but be this as it may, we suggest, in order to remedy the induction altogether, to cover each core with a metallic sheathing of some kind, carefully earthed, or, better still, connected to the outer sheathing of the cable throughout its length. It is, however, clear that such a metallic sheathing, spirally wound round each core, would have to be of exactly the same kind as the one forming the armature, as otherwise electrolytic action would destroy one of them; in case of tinfoil being employed for the purpose, the iron wire would have to be tinned. Serious practical objections would, no doubt, be raised against any such metallic sheathing of the cores in a submarine cable, and we shall therefore not pursue the subject any further. Suffice it to say that to ensure perfect screening between the cores in a telephone cable, the tinfoil must entirely and perfectly envelope each core, and an absolutely good connection must be made with the earth and the other sheathing, otherwise some induction must necessarily take place between the cores.[*]

In the "Journal of the Society of Telegraph Engineers," vol. ix., 1880, Prof. Ayrton makes a short calculation as to relative amounts of electro-magnetic and electrostatic induction from wire to wire in telegraph lines. The formula by which he arrives at the ratio between the two kinds of induction reads as follows.

$$\frac{r\left(\frac{\text{L}^2}{3} + \text{L R} + \text{R}^2\right)}{16\, d\, v^2 \log \frac{h}{d}}\text{[*]},$$

and although it does not refer to cores in submarine cables, but only to a special case on land-lines, where the distance to the ground (*h*) is great compared with the mutual distance between the wires, it will sufficiently show the effect of different conditions, and especially the enormous influence, that variation in distance between the wires plays in the ratio of the two inductions. In this latter circumstance we also fancy we catch a glimpse of an explanation to Mr. W. H. Preece's very interesting telephonic experiments on wires at a great distance from each other, where he was only able to trace electro-magnetic induction, whereas Mr. J. J. Carty, with wires in comparative close proximity to each other, demonstrated electrostatic induction only.

When considering the question as to the means adopted to overcome the mutual induction in submarine multiple core cables, we cannot but wonder how little attention has been paid to the subject, at least publicly. No doubt multiple core cables have hitherto only been employed for short sections, worked by instruments of such a kind that the disturbance between core and core is hardly, if at all, felt; but as the increasing traffic necessitates the use of sensitive and fast-speed instruments, so the induction will become troublesome, and something will have to be done to neutralise, or at all events diminish, its effect. This time is already, in fact, arrived in many instances, and, as will appear from the following, the Great Northern Telegraph Company of Copenhagen have had to take the subject seriously in had.

To Prof. Hughes we owe the "induction compensator," as described in the TELEGRAPHIC JOURNAL, March the 15th, 1879, which consists of coils of wire arranged in such a manner that the induction in the secondary wire is neutralised by an opposite current from a coil inserted therein and acted upon inductively by a similar but oppositely wound coil, placed in the primary wire. This simple principle, which is fully described in the journal, referred to above, was taken advantage of by Mr. J. Mygind, the Great Northern Telegraph Company's superintendent at Newcastle-upon-Tyne, who, in a very practical way, has managed to utilise these coils, and thus succeeded in neutralising the induction between the four land lines (each about 25 miles long) which connect the company's four North Sea cables (single core cables), landed at Newbiggin, with Newcastle.

Each induction compensator (each coil with a resistance of a few ohms) as employed by Mr. Mygind, consists of two coils wound oppositely. These coils enclose an iron core, and are fixed on a slide in order to be approached or separated at will by means of a screw. The four lines require six pairs of such compensators, and by proper adjustment a perfect balance is obtained, so that in case the different circuits are sending and receiving simultaneously, no disturbance is felt on the sensitive undulator. This instrument was described in the REVIEW, July 13th, 1888; it has been improved lately, and works now by means of a Wheatstone transmitter at the rate of 80 words a minute on the English-Swedish cables, 510—520 N.M. We may again point out here that no induction is felt when Newcastle receives on all the four wires, but the moment he sends on one or more circuits, while receiving on the others, induction at once becomes troublesome, and destroys the signals on the undulator until the anti-induction coils are applied and a counter current is sent into the receiving circuit (the secondary wire). This current must be of just sufficient strength to neutralise the inductive disturbance from the sending (primary) wire, and it is pretty evident that it is only with comparatively short land lines connected to cables which are approximately of the same length, that such a simple system of compensation (six pairs of coils) will prove adequate.

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[*] Samples of anti-induction telephone cables have been brought to our notice, in which the tinfoil only imperfectly covered the cores, leaving open spaces between each spiral.

[*] Where *r* is the radius of either wire, L the resistance of the secondary wire, R the resistance of the instrument at each end of the secondary wire, *d* the distance between the two wires (in centimetres), and *h* the height of the upper wire from the ground (also centimetres). From this it is found that the electrostatic is, roughly, *six times* the electro-magnetic induction when the lines are 500 miles long, composed of No. 8 iron wire, with a vertical distance between the two of one foot, and with the upper wire 12 feet from the ground, and a resistance at each end of the line of 1,000 ohms.

Encouraged by Mr. Mygind's success on the land lines, the same arrangement was next tried to neutralise the induction between the cores in the Great Northern Telegraph Company's two core cable between Denmark and Sweden (35 N.M.), which is also worked automatically and at high speed. The experiments were very ably conducted by Mr. Falck, the company's superintendent at Gothenburg, but no satisfactory results could be obtained, probably because the time constant of electrostatic action between the cores in the cable differs from the electro-magnetic time constant of the coils; *i.e.*, the rate of inductive action differs in the two cases. Several experiments were made with different coils, but in vain, and although it was possible to produce as powerful induction from the coils as that from the cable, yet all traces of induction could not be wiped out on the undulator slip.

FIG. 11.

We next commenced a fresh series of experiments on an artificial two-core cable, with a view of discovering some kind of compensation for their mutual inductive effect. Referring to fig. 9, we tried to insert a great resistance at *n*, but no improvement was felt, not even when *n* was made twice or three times as great as *m*. We now placed a condenser at *d*, as shown in fig. 10. By closing and opening the battery at A, *d* was charged and discharged, thereby sending a momentary current partly through *n*, and partly through B. By adjusting the resistance, *n*, more or less of the charge from the condenser will go through the galvanometer, *g*, in one direction, while the inductive impulses from B will pass through the instrument in an opposite direction, thus showing the possibility of balancing the two, and counteracting their opposite effect until no current can be seen on the galvanometer. Condensers may, of course, be applied at *s* and *t*, and A and B made to represent real resistances put to earth without altering the principle of this action.*

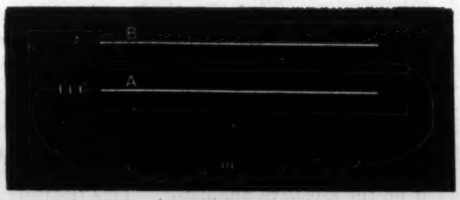

FIG. 9.

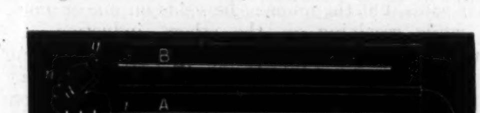

FIG. 10.

By applying the arrangement to the above-mentioned Danish-Swedish two-core cable, Mr. Falck succeeded in demonstrating the possibility of neutralising the electrostatic induction between the cores, and the work is now carried on at a high speed, messages being sent and received simultaneously on both cores, at the same end of the cable, without any appreciable interference between the cores.

Upon the Great Northern Telegraph Company's three-core cable (about 60 N.M.) connecting Woosung *via* the island of Gutzlaff with the China Sea cables, induction between the cores proved rather troublesome for some time, and interfered more or less with the work. Fig. 11 shows our system as adapted for these three cores by Mr. Schönau, the company's sub-engineer in China. By carefully adjusting the several resistances and condensers and applying values in the different branches of the circuits, as marked in the figure, perfect equilibrium is maintained, and the Thomson recorder left undisturbed in one core, while sending in one or both the others. The plan gives every satisfaction, but the drawbacks are possibly to be found in the number of condensers necessary—for three cores six condensers are needed. The first expense cannot, however, be considered serious, when the advantage of being enabled to work each core, as if it were a separate cable, is duly appreciated; it is obvious that the coils and condensers will require no readjustment after equilibrium is once established, if the cores are electrically sound.

"There is nothing new under the sun." We find, subsequently, that condensers have been in use in America, some years ago, for a similar purpose in connection with quadruplex work; but we hope, nevertheless, to have contributed in some small degree towards the settling of the disputed questions as to whether the induction between cores in the same cable is of electro-magnetic or electrostatic origin, whether such induction can be effectively screened or not, and finally to have shown some very efficient means in actual operation on cable circuits of overcoming such disturbances.

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* It is on purpose that we only refer to the galvanometer in connection with this balancing arrangement, for, as might be expected, no perfect balance can, as a rule, be obtained in the telephone. This is due mostly to the different amount of self-induction in the several coils, but also to the different inductive action of the condensers, which, as to capacity, absorption, &c., were of widely different nature. For this reason more coils must be applied in practice than used in the very simple experiment referred to above (fig. 10), *vide* fig. 11, resistances, *r*.

VARIATIONS OF CURRENT IN PRIMARY CONDUCTORS OF OPEN CIRCUIT TRANSFORMERS.

By ROBERT SHAND.*

IT is well known that a claim for high efficiency has been made on behalf of the Ruhmkorff variety of the open magnetic circuit type of transformer. The principal objections raised against its use are the large amount of copper used in its construction and the large primary magnetising current required. If such a transformer be run with its secondary conductor open circuited, or closed and carrying its maximum load, the current passing in the primary conductor will not vary between wide limits.

It has for a long time been equally well known that, if the magnetic circuit, or induction path, be closed through iron, the magnetising current is reduced to a relatively small value, and the secondary circuit being closed the currents in the conductors—primary and secondary—will rise and fall together, maintaining a nearly constant ratio for all values of the secondary load; also that by using a large quantity of iron a small quantity of copper could be used in their construction.

Apparently, considerations of this nature, coupled with its assumed high efficiency, assisted to establish the closed type in popular favour and enabled it quickly to supersede the Ruhmkorff variety of transformer in practical applications. However, the gradual accumulation of easily applied data touching the behaviour of iron when subjected to magnetising forces suggested to engineers engaged in the design of transformers modifications of such design calculated to increase the efficiency of the transformer.

To effect this improvement required that the iron used in their construction be reduced in volume, and, it being necessary to avoid the excessive absorption of power (and also magnetic leakage) incidental to a high induction, the induction per unit of core section could not be materially increased. More turns of the copper conductor were, therefore, made necessary, and their consequent increase of length required that the section be increased also in order to have the quantity C R of moderate dimensions.

To accommodate the increased volume of copper more wire space becomes necessary, and, as providing it requires that something of the increment in efficiency aimed at be foregone, a temptation arises, even in the case of the ordinary commercial closed circuit transformer, to torture the insulation by squeezing the coils into holes in the iron too small to properly receive them.

It will be observed that the development of the transformer to a point of high efficiency has been accomplished largely by the removal of iron and the addition of copper, and to the extent that this is done does the modern closed magnetic circuit transformer decrease the distance separating it from the Ruhmkorff variety of the open type in the ratio existing between the quantities of the two materials, copper and iron, entering into its construction. The desire to substitute copper for iron would thus appear to lead designers quite easily and naturally, as it were, back to the open type, in order to find room for the copper and secure the efficiency accompanying its use.

There remains to be considered the large magnetising current. Mr. Swinburne, who appears early to have grasped the conditions governing the general efficiency of the transformer, and who, in preaching the gospel of his particular "ism" has undoubtedly done much toward disseminating a knowledge of said conditions, set himself the task of reducing this large magnetising current to moderate dimensions, apparently believing that if this could be done a practical form of apparatus would be secured, having at light load an efficiency superior to that yielded by the modern closed type. His labours resulted in the production of a compromise—a kind of connecting link—which he dubbed "Hedgehog," and for which he claimed, in addition to high efficiency, that the peculiar method of construction followed resulted in a material reduction in the value of the magnetising current required. Mr. Stanley, on the other hand, discussing this subject in his article on "Plant Efficiency," made no distinction as between the "Hedgehog" and other varieties of the open type.

Both gentlemen are familiar with transformer phenomena, and expressions of opinion from them receive wide attention. As, however, they differed on this point it was thought the article,* by replying to which Mr. Stanley honours the writer, would incidentally serve to clear up the misunderstanding somewhat, inasmuch as the results there shown indicated the variety of the type to which his statement applied, and also the variety to which it did not apply, and as the latter, though much written about, was not well known, fair play demanded that its merits, whatever they were, be carefully considered before judgment regarding it be promulgated.

Mr. Stanley raises the objection that the transformer on which the observations were made was not comparable with standard commercial apparatus, the permissible drop in which he claims is 1·5 per cent.

It is true, as pointed out by the writer in the article referred to, the apparatus used was of an experimental character, and is consequently to be regarded only as an approximation to the apparatus which would be put forward to compete with highly developed representatives of the modern closed type. It may be observed, however, that the efficiency obtained was comparable with that yielded by the latter, and that the efficiency as well as the regulation could be much improved by following well-known methods. It may also be pointed out that the drop observed was greater than the calculated drop. This was undoubtedly due to magnetic leakage, causing independent back electromotive forces on the coils; this, however, ought to be largely reduced by suitable disposition of the coils.

REPLY TO MR. ROBERT SHAND ON "VARIATIONS OF CURRENT IN THE PRIMARY OF OPEN CIRCUIT TRANSFORMERS."

By WM. STANLEY, JUN.

THE point in question is one discussed by Mr. Shand in the *Electrical World* of March 21st, 1891, as to the accuracy of a statement forming part of my letter to the *Electrical Engineer* of December 10th, 1890. In order to clearly state the facts under discussion, I quote the point mentioned: "In these transformers (open magnetic circuit) the value of the primary current varies comparatively little with the load derived from the secondary circuit, and when such a transformer is gradually loaded, the primary current will remain, roughly speaking, constant, possibly varying 10 to 20 per cent." Mr. Shand questions the accuracy of this statement, furnishing figures from tests made by himself to substantiate his position. Neglecting other results, his conclusion, as shown by Table 5 of his article in the *Electrical World* of March 21st, gives the following data:

Size of transformer	1,550 watts.
Frequency	not given.
No. turns in primary	„ „
„ „ „ secondary	„ „
Resistance of coils...	„ „
Size of primary and secondary wires ...	„ „

Primary E.M.F., 100 volts; primary current, 3·27 ampères; secondary open. Primary E.M.F., 100 volts; primary current, 16·3 ampères; full load. Drop of secondary potential below normal, 3·5 volts or 3·5 per cent.

In short, in a transformer of 1,550 watts output with a 3·5 per cent. drop, the variation of primary current was from 16·3 ampères at full load to 3·27 ampères at no load; that is to say, the current fell to one-fifth of its full load value when the transformer was not doing useful work. This would certainly seem to conflict with my statement that the variation was but 20 per cent. But how about the regulation?

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* *Electrical World*, April 25th.

* See *The Electrical World*, March 21st and April 4th, 1891.

Certainly no station can use a transformer of 1,500 watts capacity having a drop of 3·5 per cent. Suppose that this transformer was compelled to regulate as well as others of standard make, the permissible drop would then be 1·5 per cent. What then would be the leakage current at a frequency of 130 periods per second? The resistance of the coils would evidently have to be decreased in the ratio of 3·5 to 1·5, or would be about 43 per cent. of the present value. Maintaining the same size of wire as used in Mr. Shand's experiment would give 43 per cent. of the turns, and with this number of turns the leakage current would be about $\left(\frac{100^2}{43^2} = 5\right)$ five times as great as he found it—viz., 17·5 ampères. So that if the same fall of potential upon the secondary circuit were allowed for the open as for the closed type of transformer, the current upon the primary circuit when the secondary was open would be as great as when the transformer was doing its full duty.

Of course this reduction of the drop of the transformer cannot be accomplished by simply taking off wire as indicated; the magnetisation of the core given at 6,300 per centimetre gives a hysteresis loss of about 2·75 watts per pound at a frequency of 133 periods per second. The core is already magnetised too high; reducing the turns to 43 would raise the magnetisation to 14,600 per centimetre, and would give an enormous loss by hysteresis, while the permeability of the core would fall so as to reduce the magnetisation. In short, the transformer made by Mr. Shand cannot be compared with the commercial apparatus; it must be redesigned for 1·5 per cent. drop.

In order to compare two types of transformers, it is necessary that they should be designed for the same output; should have the same fall of potential or drop, and the radiating surface per watt lost in the transformer should be the same; they should be subjected to E.M.Fs. of the same frequency, and then the comparison should be made upon the basis of efficiency and leakage current.

Since writing the reply to Mr. Swinburne's letter, to which Mr. Shand takes exception, I am in receipt of a letter from Swinburne & Co. stating that they can make a Hedgehog transformer of 2,000 watts output having a drop of 2·4 per cent., which will reduce the primary current to about 40 per cent. full load value when the load is taken off. Such a transformer does not regulate sufficiently well for one of 40 light capacity, as it has about 1 per cent. more drop than found in all standard closed circuit transformers of the same size in use in this country.

THE ELECTROLYSIS OF ANIMAL TISSUES.

THE first number of a journal, entitled *Studies from a Physiological Laboratory, Owen's College, Manchester*, contains an interesting contribution to our very limited knowledge of the action of electricity in relation to animal tissues. The paper is by G. N. Stewart, and has been noticed in *The Lancet*. We may briefly notice the more important of the conclusions arrived at—conclusions, it may be added, which are in every case fair deductions from experimental results, and not, as is too often the case with the literature of this subject, mere "quack twaddle."

It seems that practically the whole of the conduction in animal tissues is electrolytic, and the electrolytes are principally the mineral salts, changes in the proteids being produced by secondary electrolytic actions.

In simple proteid solutions, conduction occurs with great difficulty if mineral salts are absent, or if they are present only in small proportions. The effects on the proteids themselves in saline solutions vary somewhat with the current density. Alkali-albumin is formed at the cathode, and acid-albumin at the anode; whilst in solutions of coagulable proteids there is also coagulation at the latter pole. With a strong current, the proportion of coagulated proteid to acid-albumin is greater than with a weak current.

In bile and urine it was observed that the conduction is also chiefly due to electrolysis in the mineral substances, and not in the organic substances contained in these secretions.

In blood, the changes which take place in the proteids are similar to those which are mentioned above. There is also a formation of acid-hæmatin (mixed with or preceded by methæmoglobin with certain strengths of current) and of alkali-hæmatin at the anode and cathode, respectively. There is no evidence that hæmoglobin or any of its derivatives can act as an ion.

In muscle, the nuclei become apparent, and the sarcous substance granular at the anode; this is the appearance always produced by a weak acid. At the cathode the fibres become more homogeneous. The chief chemical changes in proteids are an increase in the neutralisation precipitate of the aqueous extract, and a corresponding decrease of the globulin. At the anode, the neutralisation precipitate is increased, but the amount of globulin is more than correspondingly diminished, because part of this proteid is coagulated.

The effects of electrolysis on the salts of the muscles were studied by estimating the ash. Striking changes were found to occur which if produced within the living body, would profoundly modify nutrition.

The antiseptic action of the current was studied in the case of micro-organisms, and it was found to occur chiefly, if not entirely, around the anode.

In another and later paper specially devoted to the electrolysis and putrefaction of bile, Mr. Stewart shows that when bile is electrolysed in a U tube, changes take place at the negative pole, which are similar to those which occur when bile is allowed to putrefy, that is the pigment changes to brown through light shades, ultimately becoming yellow. In the early stages of the electrolysis a reversal of the current restores the original colour.

The anode has an oxidising, the cathode a reducing action upon bile. The bile salts are electrolytes, and an acid constituent of these crystallises at the anode in long needles; but the conductivity of bile salts is small as compared with that of the inorganic constituents of the secretion.

With these results for bile we may compare those obtained by J. B. Haycraft and H. Scofield (*vide Zeit. Physiol. Chem.*, xiv., 173). In the course of their researches they showed that a play of colours is obtained at the positive pole of a battery (four Grove cells) placed in the bile, indicating successive stages of oxidisation; if the negative pole be then placed in the bile, the effects are reversed, indicating reduction.

Mr. Stewart makes some attempt to connect this knowledge of the electrolysis of animal tissues with the application of electrolysis in surgery, and promises a further communication on the physiological aspects of the question.

ELEMENTARY ANALYSIS BY A NEW ELECTRO-THERMAL METHOD.

ELEMENTARY organic analyses are commonly effected in laboratories by what are known as combustion processes; the substance to be analysed is placed in a long glass tube and heated in proximity to copper oxide, &c., and the products of combustion are then examined.

Electricity has been applied to the analysis of gases in the eudiometer, and also in many cases of what are called electrolytic separations; we are not aware, however, that it has been applied to the analysis of organic substances until quite recently. J. Oser has just worked out an entirely new method, which may be described as electro-thermal.

The new method partakes of the nature of the old combustion process, of which it is really, perhaps, a modification. The substance to be burnt is placed in a small porcelain dish which is surrounded by a coil of thin platinum wire, and is contained in an ordinary hard combustion tube. A stream of pure oxygen gas is allowed to flow steadily along the tube, and at the same time the platinum wire is heated to redness by means of an electric current, the wires being kept insulated by passing through narrow apertures in a porcelain cylinder fitting into the tube. In order to ensure perfect combustion, all the products of combustion together with the excess of oxygen are led through a narrow aperture in the porcelain cylinder filled with granular copper oxide and heated to a high temperature by an electrically ignited platinum wire which also passes through this aperture.

A number of precautions appear to be necessary in order to ensure satisfactory results by this method, and these, together with a table of numerical results which Oser has obtained, are given in the original paper (*vide Monatshefte*, xi., 486—500); a sketch of the apparatus is also given.

Oser is engaged in attempting to develop his method so that in one apparatus may be determined both the elementary analysis and the heat of combustion of any given organic substance.

ELECTROSTATIC INDUCTION.

By K. GULSTAD.

Whilst investigating the phenomena of mutual induction between continuous cores in multiple core cables, I was led to make some experimental researches with condensers, the practical result of which is dealt with in a paper by Mr. Dresing and myself, entitled, "Remarks on induction in multiple core cables." Other parts of the experiments I hereby present to your readers.

The condenser arrangement was as fig. 1 shows; *h* being a battery, *g* a telephone, A, B, *a*, b^1, b^2, *c* the condenser plates, and *m* a wire of thick copper.

When depressing (or raising) the battery key (not shown in fig. 1), no sound whatever could be heard in the telephone; but on substituting for the thick wire, *m*, a thin German silver one, sounds could be distinctly heard. A mirror galvanometer was then employed instead of the telephone, but the spot of light did not move until rather great resistances, *m*, were inserted. The thus produced deflections, returning to zero, indicated a charge rushing into A. What caused these deflections? I could not explain it otherwise than by assuming that the charging of $B - \frac{b^2}{c}$ and the thereby supposed "screening" action of b^2 was retarded for a moment by the inductance of *m*. This would then cause the condenser $A - \frac{a}{b_1}$ to be momentarily charged inductively *via* b^2, and —as it does not maintain the charge—again discharged as soon as the inductance to the charging current, *via m*, was overcome.

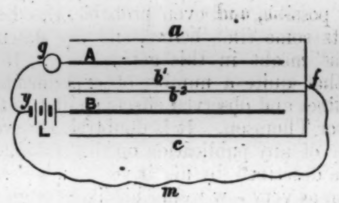

Fig. 1.

Upon the sluggishly acting mirror galvanometer I should not, of course, have observed anything, the charges and discharges of condenser $A - \frac{a}{b^1}$ being equal in magnitude, if the inductance of *m* had not retarded the discharge a little in relation to the charge. In fact, the deflection must be caused by the difference in time rate for a series of charging and discharging currents corresponding to the sum of the differences in, say, the amplitudes for the charging and retained discharging undulatory oscillations. The deflection shows exactly that not one, but a series of oscillations are going on, the movement of the spot of light being suddenly stopped and the light attaining an appearance of a blur when the deflection has reached its maximum, just as if they in some way were produced by more sluggishly acting oscillations of smaller amplitude, in accordance with the well-known theoretical shape of the discharging curve for condensers.

When raising the key we get the same* deflections in opposite direction. Remembering that $A - \frac{a}{b^1}$ does not keep any charge, this can only be due to the momentary discharging of condenser $B - \frac{b_2}{c}$ into condenser $A - \frac{a}{b^1}$. The resulting currents are then oscillating in unison in both condensers, the points, *x* and *y*, being turning points besides starting points for the path of the original charging current into $A - \frac{a}{b_1}$.

The theory for the oscillatory character of charges and discharges of condensers (Leyden jars) is thus here demonstrated by experiment.

The deflections were proportional to the resistance of the wire, *m*, as far as could be observed, and as might be expected.

Next resistances, *p*, were inserted at *n* (fig. 2), and it was expected that this would affect the deflections, the time given to plate, b^2, to exert its screening action now being altered. But no sign of this was observed, even when *p* was made twice or thrice the value of *m* (10,000 ohms), nor could any difference be seen when the same resistances were applied directly to the battery at *o*.

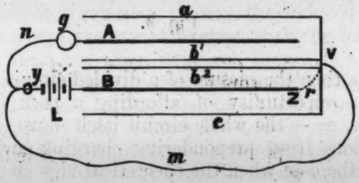

Fig. 2.

It was at first, when the resistances amounted to 100,000 ohms, that in both cases the same small apparent diminution of the deflections could be seen by their clearing the blur and making the readings more distinct.

This means, I think, the experimental proof that the plate, b^2, by itself cannot exert any screening effect, or that the electrostatic induction cannot be screened off. What happens is really that the so-called screened part, being quite unaffected by the screen, b^2, must be subject to a momentary series of charging and discharging currents until electrostatic equilibrium is re-established. The strength of these currents, which is at first determined partly regardless of the shunt, *m*, is gradually dying away, according as the action of the shunting wire is increasing and its inductance overcome.

The said deflections decreased when inserting a condenser between the terminals of *m*, the condenser thus acting as a shunt circuit to *m*.

Having demonstrated (see fig. 2) that b^2 cannot withhold any charge from b^1, but merely is acting as a conductor for electricity, we observe that it does not alter the matter principally; if we, instead of $B - \frac{b^2}{c}$, joined points *x* and *z* by a wire, *r* (the dotted line), having some resistance, the potential difference from *y* to *x*, and thence the effect on the galvanometer would, however, be reduced, unless *m* is very large in comparison to *r*. Fig. 3 illustrates this case, the figures being the same as at fig. 2.

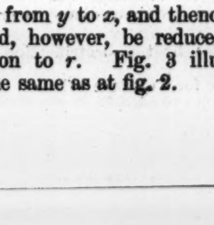

Fig. 3.

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* Condenser $B - \frac{b^2}{c}$ and condenser $A - \frac{a}{b^1}$ had each a capacity = 0.17 mcfrd.

The condenser arrangement $A - \frac{a}{b^1}$ is subjected to a series of charging and discharging currents whose interference causes us to observe the phenomena as described, but when m has got any resistance the charging currents are preponderating in a certain direction, and we say the condenser has got a charge.

We don't generally see the blurr, this being too small in comparison with the charging deflections.

Reducing the size of the condenser plates, viz., the capacity, and, for instance, only employing rods with blunt ends, will greatly diminish the magnitude of the deflection. Still the oscillations must take place even if we, instead of the dielectric between the ends, inserted a wire possessing inductance.

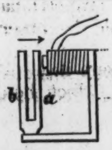

FIG. 4.

We have then the picture of a divided circuit, each branch having an opportunity of affording a path for electrical oscillations, or — the whole circuit itself must be subjected to oscillations from prepondering charging currents. Such is at least the case when the theoretical view is correct, that a commencing current, for a very short time, is proceeding with different strengths through the interior and the outer skin of a conductor. These momentary acting currents, the reactions of which, whenever they meet resistances in their way, are causing the phenomena generally named "self-induction," to pass into those that are maintained by the source of electricity when there are no condensers in the circuit.

The momentary electrostatic disturbance giving rise to the named currents must, through static induction, produce similar disturbances, but of opposite character, upon other bodies in the neighbourhood. The thus occasioned derived current (electro-magnetic induction) must then in its turn be the result of a series of rapidly vanishing oscillating currents.

Upon the subject I may here still once more refer to the blurring appearance of the spot of light. Larger resistances (inserted at n or o, fig. 2) did, as stated, do away with the blur by reducing the amplitude of the oscillation. Water inserted instead of resistance, m (fig. 1), produced some peculiarities to be observed; for instance,* the deflection when zinc pole was to B was larger than with copper pole to B instantly after, &c. Similar discrepancies seemed to take place when smaller resistances were employed, and can be accounted for by assuming that discharges reacted on the battery. The blur prohibited, unfortunately, exact readings being taken, but, if it be so, it would in another way demonstrate that oscillations caused by the charging of $B - \frac{b^2}{c}$ would be in unison with those regarding $A - \frac{a}{b^1}$. There does then happen something like what happens when (see fig. 4) sending a steady electric current through an electro-magnet, the magnetism of which only acts upon one branch, a, of an iron tuning fork, a b. Nevertheless, the branch, b, will commence and continue to oscillate in unison with a, and the iron frame, c, till all parts simultaneously come to rest, although the attraction between a and the electro-magnet is maintained.

True, it is here a purely mechanical reason that causes b to vibrate, but I may suggest that a direct action on b, due to the electro-magnet in the direction of the arrow would take place, if the magnetic permeability of the iron in leg a was much less than that in leg b.

Referring to the experiments previously mentioned, it may perhaps not be found without interest to quote the following result of a rough test.

m = 100,000 ohms (German silver 0·1 mm.) was found corresponding to 0·00435 microfarads; this latter magnitude being calculated from the blurring deflection that indicated how much the passage of electricity had been retarded by the resistance, m.

PHENOMENA OF ALTERNATING CURRENTS OF VERY HIGH FREQUENCY.*

BY NIKOLA TESLA.

THE following letter refers to Prof. Thomson's reply, published in our issue of April 17th :—

I cannot pass without comment the note of Prof. Thomson in *The Electrical World* of April 4th, although I dislike very much to engage in a prolonged controversy. I would gladly let Prof. Thomson have the last word, were it not that some of his statements render a reply from me necessary.

I did not mean to imply that whatever work Prof. Thomson has done in alternating currents of very high frequency was subsequent to his letter published in *The Electrician*. I thought it possible, and even probable, that he had made his experiments some time before, and my statement in regard to this was meant in this general way. It is more than probable that quite a number of experimenters have built such machines and observed effects similar to those described by Professor Thomson. It is doubtful, however, whether, in the absence of any publication on this subject, the luminous phenomena described by me have been observed by others, the more so as very few would be likely to go to the trouble I did, and I would myself not have done so had I not had an advance of firm conviction gained from the study of the works of the most advanced thinkers that I would obtain the results sought for. Now that I have indicated the direction, many will probably follow, and for this very purpose I have shown some of the results I have reached.

Prof. Thomson states decisively in regard to the experiment with the incandescent lamp bulb and the filament mounted on a single wire that he cannot agree with me at all that conduction through the glass has anything to do with the phenomenon observed. He mentions the well-known fact that an incandescent lamp acts as a Leyden jar and says that "if conduction through the glass were a possibility this action could not occur." I think I may confidently assert that very few electricians will share this view. For the possibility of the condenser effect taking place it is only necessary that the rate at which the charges can equalise through the glass by conduction should be somewhat below the rate at which they are so stored.

Prof. Thomson seems to think that conduction through the glass is an impossibility. Has he then never measured insulation resistance, and has he then not measured it by means of a conduction current? Does he think that there *is* such a thing as a perfect non-conductor among the bodies we are able to perceive? Does he *not* think that as regards conductivity there can be question only of degree? If glass were a perfect non-conductor, how could we account for the conduction through a glass condenser when subjected to steady differences of potential?

While not directly connected with the present controversy, I would here point out that there exists a popular error in regard to the properties of dielectric bodies. Many electricians frequently confound the theoretical dielectric of Maxwell with the dielectric bodies in use. They do not stop to think that the only perfect dielectric is ether, and that all other bodies, the existence of which is known to us, must be conductors, judging from their physical properties.

My statement that conduction is concerned to some, though perhaps negligible, extent in the experiment above described was, however, made not only on account of the fact that all bodies conduct more or less, but principally on account of the heating of the glass during the experiment. Prof. Thomson seems to overlook the fact that the insulating power of glass diminishes enormously with the increase in temperature, so much so that melted glass is comparatively an excellent conductor. I have, moreover, stated in my first reply to Prof. Thomson in *The Electrical World* of March 21st, 1891, that the same experiment can be performed by means of an unvarying difference of potential. In this case it must be assumed that some such process as conduction through the glass takes place, and all the more as it is possible to show by experiment that with a sufficiently high steady difference of potential enough current can be passed through the glass of a condenser with mercury coatings to light up a Geissler tube joined in series with the condenser. When the potential is alternating the condenser action comes in, and conduction becomes insignificant, and the more so the greater the rate of alternation or change per unit of time. Nevertheless, in my opinion, conduction must always exist, especially if the glass is hot, although it may be negligible with very high frequencies.

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* A kind of sluggish discharge was observed when the galvanometer key was pressed down immediately after the battery key, and not to be accounted for by the electrification between plates $A - \frac{a}{b^1}$ for an electromotive force of some volts.

* *Electrical World.*

Prof. Thomson states further that, from his point of view, I have misunderstood his statement about the limit of audition. He says that 10,000 to 20,000 alternations correspond to 5,000 to 10,000 complete waves of sound. In my first reply to Prof. Thomson's remarks (in the *Electrical World* of March 21st, 1891) I avoided pointing out directly that Prof. Thomson was mistaken, but now I see no way out of it. Prof. Thomson will pardon me if I call his attention to the fact he seems to disregard, namely, that 10,000 to 20,000 alternations of current in an arc—which was the subject under discussion—does not mean 5,000 to 10,000, but 10,000 to 20,000 *complete waves of sound.*

He says that I have adopted or suggested as the limit of audition 10,000 waves per second; but I have neither adopted nor suggested it. Prof. Thomson states that I have been working with 5,000 to 10,000 complete waves, while I have nowhere made any such statement. He says that this would be working below the limit of audition, and cites as an argument that at the Central High School in Philadelphia he has heard 20,000 waves per second; but he wholly overlooks a point on which I have dwelt at some length—namely, that the limit of audition of an arc is something entirely different from the limit of audition in general.

Prof. Thomson further states, in reply to some of my views expressed in regard to the constant current machines, that five or six years ago it occurred to him to try the construction of a dynamo for constant current, in which "the armature coils were of a highly efficient type, that is, of comparatively short wire length for the voltage and moving in a dense magnetic field." Exteriorly to the coils and to the field he had placed in the circuit of each coil an impedance coil which consisted of an iron core wound with a considerable length of wire and connected directly in circuit with the armature coil. He thus obtained, he thought, "the property of considerable self-induction along with efficient current generation." Prof. Thomson says he expected "that possibly the effects would be very much the same as those obtainable from the regularly constructed apparatus." But he was *disappointed*, he adds. With all the consideration due to Prof. Thomson, I would say that to expect a good result from such a combination was rather sanguine. Earth is not farther from heaven than this arrangement is from one in which there would be a length of wire sufficient to give the same self-induction wound on the armature and utilised to produce useful E.M.F. instead of doing just the opposite, let alone the loss in the iron cores. But it is, of course, only fair to remember that this experiment was performed five or six years ago, when even the foremost electricians lacked the necessary information in these and other matters.

Prof. Thomson seems to think that self-induction wipes out the periodical undulations of current. Now self-induction does not produce any such effect, but if anything, it renders the undulations more pronounced. This is self-evident. Let us insert a self-induction coil in a circuit traversed by an undulating current and see what happens. During the period of the greatest rate of change when the current has a small value, the self-induction opposes more than during the time of the small rate of change and when the current is at or near its maximum value. The consequence is that with the same frequency the maximum value of the current becomes the greater, the greater the self-induction. As the sound in a telephone depends only on the maximum value, it is clear that self-induction is the very thing required in a telephone circuit. The larger the self-induction the louder and clearer the speech, provided the same current is passed through the circuit. I have had ample opportunity to study this subject during my telephone experience of several years. As regards the fact that a self-induction coil in series with a telephone diminishes the loudness of the sound, Prof. Thomson seems to overlook that this effect is wholly due to the impedance of the coil, *i.e.*, to its virtue of diminishing the *current's strength.* But while the current's strength is diminished the undulation is rendered only more pronounced. Obviously, when comparisons are made they must be made with the same current.

In an arc machine, such as that of Professor Thomson's, the effect is different. There one has to deal with a make and break. There are then two induced currents, one in the opposite the other in the same direction with the main current. If the function of the mechanism be the same, whether self-induction coil be present or not, the undulations could not possibly be wiped out. But Prof. Thomson seems likewise to forget that the effect is wholly due to the defect of the commutator; namely, the induced current of break—which is of the same direction with the main current and of great intensity when large self-induction is present—simply bridges the adjacent commutator segments, or if not entirely so, at least shortens the interval during which the circuit is open, and thus reduces the undulation.

In regard to the improvement in the feeding of the lamps by vibration or undulations, Prof. Thomson expresses a decisive opinion. He now says that the vibrations *must* improve the feeding of a clockwork lamp. He says that I "contented myself by simply saying" that I cannot agree with him on that point.

Now, *saying it* is not the only thing I did. I have passed many a night watching a lamp feed, and I leave it to any skilled experimenter to investigate whether my statements are correct. My opinion is that a clockwork lamp—that is, a lamp in which the descent of the carbon is regulated not by a clutch or friction mechanism, but by an escapement—cannot feed any more perfectly than tooth by tooth, which may be a movement of, say, one-sixty-fourth of an inch or less. Such a lamp will feed in nearly the same manner, whether the current be perfectly smooth or undulating, provided the conditions of the circuit are otherwise stable. If there is any advantage I think it would be in the use of a smooth current, for with an undulating current the lamp is likely to miss some time and feed by more than one tooth. But a lamp in which the descent of the carbon is regulated by friction mechanism, an undulating current of the proper number of undulations per second will always give a better result. Of course to realise fully the benefits of the undulating current the release ought to be effected independently of the up and down movement, as I have pointed out before.

In regard to the physiological effects Prof. Thomson says that in such a comparatively poor conductive material as animal tissue the distribution of current cannot be governed by self-induction to any appreciable extent, but he does not consider the two-fold effect of the large cross-section pointed out by Sir William Thomson. As the resistance of the body to such currents is low, we must assume either condenser action or induction of currents in the body.

BY ELIHU THOMSON.

IT is not from any desire to have the last word that I have answered Mr. Tesla's statements as they appeared.* It has simply been to correct misunderstandings. In regard to the experiment which I mentioned as performed by immersing in water a lamp bulb in which a single strip of carbon had been mounted, and connecting the water and the filament to a source of high potential alternating current at high frequencies, and whereby the strip of carbon was brought to bright incandescence, I simply said that conduction through the glass could not have had any effect in this experiment. I made no general denial that a slight conduction occurred with even the best dielectrics. The glass in my experiment being immersed in water, the assumption of high temperature which Mr. Tesla makes, as increasing the conductivity of the glass, is not to be considered in this case. The glass was only heated where it was not so immersed, and where, therefore, no connection with the circuit existed.

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* See the *Electrical World*, April 11th, 1891.

Mr. Tesla bases a long statement about dielectrics, insulation resistance, perfect conductors, degrees of conductivity, &c., on the statement I made in relation to the experiment and the phenomenon it presented; and he even asks whether I have "then never measured insulation resistance" and "by a conduction current." Similar irrelevant questions follow this typical one. I had said that "if conduction through the glass were a possibility" (in the experiment and accounted for the phenomenon presented) "this action" (of charging a lamp bulb as a Leyden jar and receiving a charge therefrom) "could not occur." Mr. Tesla does me the injustice of applying a statement, which related to a particular experiment and phenomenon, to classes and conditions of phenomena which any one at all familiar with the circumstances would rule out. Mr. Tesla says: "My statement that conduction is concerned to some, *though perhaps negligible*, extent in the experiment above described was, however, made not only on account of the fact that all bodies conduct more or less, but principally on account of the *heating of the glass* during the experiment." The italics are mine. In the experiment the glass was immersed in cold water and only that portion not immersed and not in contact with the current conductor or the surrounding water was warmed. This disposes of the paragraph of contentions of Mr. Tesla based on heated glass in the experiment.

In regard to the estimate of the number of complete waves of sound corresponding to a given number of alternations, I freely confess that I was in error, and that the number given by Mr. Tesla is correct. The number of complete sound waves does, as Mr. Tesla points out, correspond to the number of alternations, as the expansion and the contraction of the arc stream corresponding to wave condensation and rarefaction occur with each alternation. This is a point which I had missed in the former consideration of the matter, but, of course, if the limit of audition is above any of the rates considered, it would not affect the argument except as it relates to the degree of approximation to that limit.

Without calling upon Mr. Tesla to state how far "earth is from heaven" in his view, I will simply state that my experiment of five or six years ago, which called forth his remark, certainly did teach me something then, and added somewhat to my information in certain directions.

I was perfectly well aware of the effects of self-induction, including impedance, pointed out by Mr. Tesla, when I spoke of the insertion of a coil of large self-induction into a circuit of arc lights as steadying the current and lessening its undulations. In regard to the effects of self-induction, I may state that the property of impedance I have always regarded as one of those effects. It is not true, as stated by Mr. Tesla, that self-induction "renders the undulations more pronounced." Whether it will do so or not depends on the shape of the wave of undulation. Not all shapes of wave have the greatest rate of change when the current has a small value. What is true in this respect of a sine curve would not be true of a saw-tooth wave. But the point under discussion, originally, was the effect of a large self-induction interposed in a circuit of arc lights, in which the current was of a fluctuating character. The current may be considered in this case as made up of a steady current of an average current value, upon which has been superimposed an alternating current of small value, or it may be considered as made up of a steady current of less than the average value with a pulsating current of small value superimposed. These assumptions to be exact, of course, are made on the basis that in the fluctuations the strength of the current does not change very greatly, or that the minimum current and the maximum current values are not far removed from the average value.

Now, the effect of self-induction introduced into such a circuit with arc lights is, by its impedance, to diminish the value of that portion of the current which is, so to speak, alternating or fluctuating, and whether the waves of alternating or pulsating currents, so greatly diminished in amplitude, will be sharpened or smoothed out by self-induction will depend upon their original form. It is the effect of self-induction in producing impedance, and, therefore, restricting the value of the fluctuating or alternating current strength, superimposed on the much larger constant or steady current, to which I referred in speaking of the smoothing action. Mr. Tesla was right in his general statements of principle, but wrong in his application of them to the case in point. He was not right, however, in separating the effect of impedance from self-induction in the case under discussion.

I have no desire to prolong this discussion, and will leave out of consideration any reference to effects on clutch or clockwork lamps, or to the physiological effects of currents. I have in the above comments confined myself strictly to those matters which it seemed necessary to have cleared up in some way. I hope that, in stating my position in relation to the matter, I have made myself cleat so as to avoid further misunderstandings.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.*

On Some Effects of Alternating Current Flow in Circuits Having Capacity and Self-Induction.

By Dr. J. A. Fleming, Member.

(*Concluded from page* 636.)

15. In the course of various experiments during the laying of the cable, it became evident that a conductor having so considerable an electrostatic capacity behaved in a curious manner under some circumstances when long lengths were connected up to a transformer. This behaviour has been much misunderstood, and much misdescribed. Remarkable phrases have been coined with reference to it, such as "the piling up of the volts," or "packing up of the volts," which are not very lucid descriptions of what really does occur. Ingenious theories have been constructed also to account for phenomena which do not exist. Briefly stated, it appears to be as follows:—When an insulated and sufficient length of the cable has its inner and outer members connected to the terminals either of a transformer or of an alternator having an armature of sufficient inductance, it is observed that under these conditions the potential difference between the inner and outer members, measured anywhere along the length of the cable, is generally greater than would be the potential difference of the terminals of that alternator or transformer if the cable were very short, or not present at all. This seems to hold good also when the far ends of the inner and outer members are connected together through a not very small resistance, such as a row of incandescent lamps in series, or a high resistance voltmeter, or transformer lightly loaded. The cable acts in all apparently as one single condenser would do, and in no case, as far as is known, is there evidence of a continuous rise of pressure along the trunk mains themselves. The pressure at the London end is not found to be greater than at the Deptford end. The condenser effect is increased apparently by increase of length of the main, at least within observed limits, and in all cases the main acts as if it were a condenser bridged across between two parallel mains without capacity. When current flows into the cable there is a flux across the dielectric from inner to outer member which constitutes the *condenser current* of the mains, and the overflowing current is in general less in magnitude than the inflowing current, although not always necessarily so. The current flowing out at the London end may be called the *work current*. There is a difference in phase between the work current and the condenser current. The ingoing current is the resultant of the work and condenser current.

16. In order to examine the phenomena of these trunk mains more closely, some experiments were made on one long length of nearly 12 miles of the cable by joining the conductors of two trunk mains in London, and having both ends of this gigantic loop of concentric cable at our disposal in the Deptford station. These experiments were arranged by Mr. Ferranti to give Mr. Preece, Major Cardew, and me the opportunity of obtaining measurements of these condenser effects in the Ferranti trunk mains. The experiments were made on Friday, January 9th, 1891, at Deptford, and Mr. Ferranti, Mr. Sparks, Mr. D'Alton, Mr. McLean, and the assistant engineers took part in carrying out these measurements. The arrangements were made as follows (see fig. 10):—One of the 1,200-H.P. dynamos (No. 2) was set apart for the purpose, and excited so as to supply current at about 2,500 volts or so. The current from this dynamo was led through the primaries of two 150-H.P. transformers joined in parallel, and which raised the pressure from 2,500 to 10,000 volts. At this pressure a current from the secondaries was sent into the concentric cable at Deptford, thence to the sub-station in Trafalgar Square in London by one main, and back to Deptford on the other trunk main. This total distance is 20,224 yards, or 11·49 statute miles. Arriving back at Deptford, the current was again reduced from 10,000 to 2,500 volts, and the energy taken up in water resistance in a water tank at the latter pressure. The pressure at different parts of the system was

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* Paper read May 7th, 1891.

measured by Cardew voltmeters, the high pressures being reduced by 100 : 1 pilot transformers. The currents were measured by Evershed ammeters. The current and pressure were measured at four places—viz., at the terminals of the dynamo, at the beginning, or entrance of the trunk main, at the end of the trunk main, and, after reduction, at the tank.

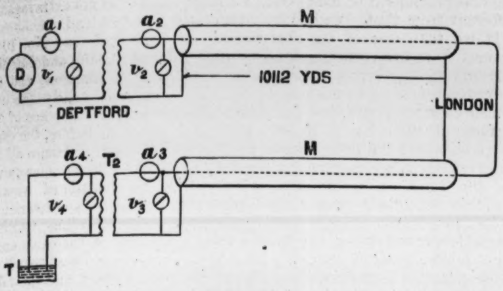

FIG. 10.

Observers stationed at these different instruments took simultaneous observations at a signal given by the sound of a whistle, and in this way the simultaneous values of the pressure and current were obtained at these four places. The transformers used for raising and lowering the pressure were the 150 H.P. size, having on the primary side 1,120 turns of wire, of resistance 3·5 ohms, and on the secondary side 280 turns of wire, having a resistance of ·2442 ohms. Hence these transformers were 4 : 1 transformers. There were, in addition, a pair of pilot transformers, which had a change ratio of 100 : 1, and which reduced from 10,000 to 100 volts for voltmeter purposes. The observations consisted in exciting the dynamo to various voltages, and observing the current and pressure at the four places named, whilst different loads were placed on the system by taking up more or less current in the tank.

TABLE I.—EXPERIMENTS ON THE PRESSURE DISTRIBUTION IN THE FERRANTI TRUNK MAINS.

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.
No. of experiment.	At dynamo terminals.		Dynamo pressure multiplied by 4.	At home end of trunk main.		At far end of trunk main.		Pressure at tank multiplied by 4.	At the tank.	
	Pressure.	Current.		Pressure.	Current.	Pressure.	Current.		Pressure.	Current.
1	2,177	121·4	8,708	9,060	29·2	8,950	26·5	8,640	2,160	118·2
2	2,386	119·4	9,544	10,100	31·5	9,770	28·0	9,504	2,376	117·1
3	2,458	119·4	9,832	10,300	32·0	10,120	28·0	9,840	2,460	116·0
4	2,177	119·3	8,708	9,110	29·2	8,930	26·5	8,640	2,160	116·0
5	2,311	113·2	9,244	9,700	28·7	9,570	24·8	9,408	2,352	106·5
6	2,251	110·2	9,004	9,600	27·6	9,280	24·3	9,024	2,256	105·5
7	2,568	106·1	10,272	10,490	27·0	10,070	23·3	9,792	2,448	101·6
8	1,994	108·1	7,976	8,420	26·0	8,200	23·3	7,872	1,968	100·7
9	2,448	100·0	9,792	10,170	24·0	10,690	19·0	10,128	2,532	56·6
10	2,496	92·8	9,984	10,560	22·0	10,590	17·0	10,512	2,628	56·0
11	2,400	92·8	9,600	10,360	21·5	10,490	16·3	10,224	2,556	55·5
12	2,311	64·1	9,244	9,700	17·0	9,770	Not taken	9,600	2,400	42·2
13	2,280	41·7	9,120	9,870	11·0	9,900	0	9,736	2,434	0
14	2,328	41·7	9,312	9,970	11·0	10,000	0	9,880	2,470	0
15	1,620	42·7	6,480	7,240	10·0	7,350	0	7,248	1,812	0
16	1,104	24·4	4,416	5,200	5·0	5,200	0	4,964	1,241	0
17	1,212	24·4	4,848	5,500	9·0	5,500	0	5,456	1,339	0
18	1,308	24·4	5,232	5,900	9·0	5,900	0	5,740	1,435	0
19	1,800	37·6	7,200	7,920	10·0	7,920	0	7,784	1,946	0
20	2,136	48·8	8,544	9,380	12·0	9,410	0	9,244	2,311	0

17. From a large number of observations the following are selected as showing the general results obtained, and are set forth in Table I. The first column gives a number for each experiment. The second and third give the pressure and current at the dynamo terminals. The fourth column is a series of numbers which are four times those in the second column, and are the pressures to which the 1 : 4 step-up transformers at the home end would raise the dynamo pressure if the cable were absent. The fifth and sixth columns give the pressure and current at the home, or dynamo, end of the trunk main, and it will be seen that in every case this observed pressure is greater than four times the pressure at the dynamo terminals. The seventh and eighth columns give the pressure and current at the far end of the trunk main, and it will be seen that in every case the current flowing out of the main is less than that going into it. Columns ten and eleven give the pressure and current after reduction by the step-down transformers, at which pressure the energy was taken up on water resistance in a tank. Column nine gives the pressure on the primary, or cable, side of the 4 : 1 step-down transformers, which would be necessary to give the pressure observed at the tank if the cable were not present.

18. We have then to see how these observed values agree with theory. It must be, however, stated that these numbers and values so observed are not minutely accurate. Owing to the fact that the speed of the dynamo varied slightly, and to the fact that the Cardew voltmeters used were set vertical, and not horizontal, some degree of inaccuracy exists in the readings of current and pressure, but the figures are perhaps sufficient to test the general agreement of fact with theory.

We note, first, that in the experiments at full load, when 118 ampères was being taken up in the resistance, the load on the transformers was about 340 H.P., and hence the two 150 H.P. transformers at each end joined in parallel were slightly overloaded. Under these circumstances, the inductance of the transformers at the step-up end is reduced practically to a very small value, and we may consider that the actual current of 30 ampères or so flowing in the cable can be considered to be the resultant of two superimposed currents differing about 90 degrees in phase from one another. There is, first, the *work* current of 26·5 ampéres in Experiment I., which is flowing out of the cable, and which is practically in synchronism with the impressed electromotive force in the secondary circuit of the step-up transformers. Then there is the *condenser* current of the cable considered as one single condenser, which will be 90 degrees in advance in phase of the impressed electromotive force creating this charge. Hence the values of the ingoing currents given in column VI. are the resultants of the outgoing currents given in column VIII., and the condenser current of the cable, which is in quadrature with the last. Hence the magnitude of the condenser current must be the square root of the difference of the squares of the currents given in columns VI. and VIII., which may be called respectively the *resultant current* and the *work current.*

Taking the first six experiments in Table I., we calculate from them the square root of the difference of the squares of the currents in columns VI. and VIII. of Table I., and write them as in Table II. below

TABLE II.

Resultant current going into cable $= a$.	Work current coming out of cable $= b$.	Condenser current of cable $= \sqrt{a^2 - b^2}$.
Ampères.	Ampères.	Ampères.
29·2	26·5	12·2
31·5	28·0	14·4
32·0	28·0	15·5
29·2	26·5	12·2
28·7	24·8	14·4
27·6	24·3	13·1

Unfortunately, the speeds of the dynamo were not taken at each observation; but the normal frequency of the current from these dynamos is 67, and in these experiments the dynamo speeds were marked as rather below the normal. If $n = 67$, $2 \pi n = p = 421$. It is probable that the value of p was not greater than 400 in these experiments. We have seen (equation 2, *ante*) that if v is the instantaneous potential difference of the condenser terminals, and i the current flowing into it at any instant, $i = \mathrm{C} \frac{d\,v}{d\,t}$. Hence, on the assumption of a simple periodic variation of the current, we may write p for $\frac{d}{d\,t}$, and put as the value of the square root of the mean square of the condenser current, I, the expression,

$$\mathrm{I} = p\,\mathrm{C}\,\mathrm{V},$$

where C is the capacity, and V is the potential difference of the terminals of the condenser as read by an electrostatic or Cardew voltmeter. It then follows that the capacity of the cable is determinable from the values of the condenser current, I, the pressure, V, as read at the step-up end, and from the known value of p.

We may examine how far the capacity value so deduced agrees with measurement.

We tabulate in columns the values of the condenser currents, I, found from Table II., and set against these the mean potential difference of the inner and outer members of the cable as the mean potential difference of the surfaces of the condenser. Calling these last values V, we then calculate the capacity C, in microfarads from the formula,

$$\mathrm{C} = \frac{\mathrm{I}}{p\,\mathrm{V}} \times 10^6,$$

on the assumption that $p = 400$. These results are set down in Table III. The values of the potential, V, are the means of the pressures given in columns V. and VII. of Table I. as the pressures at the step-up and step-down end of the trunk main.

TABLE III.

Condenser currents, I, in ampères, taken from Table II.	Mean potential difference of condenser surfaces, V, of cable, in volts.	Calculated capacity for the whole length of cable, in microfarads.
12·2	9,005	3·4
14·4	9,935	3·6
15·5	10,210	3·8
12·2	9,020	3·4
14·4	9,635	3·7
13·1	9,440	3·5

The mean electrostatic capacity of the 11·5 statute miles of the cable in use is therefore about 3·6 microfarads, as deduced from these experiments. On the day following these experiments the electrostatic capacity was measured at Deptford by Mr. H. R. Kempe, using a microfarad standard and a battery of about 18 Daniell cells, and taking galvanometer throw observations in the usual way. Mr. Kempe found the capacity under these circumstances of the respective mains to be about 1·98 and 2·02 microfarads, or in all about 4 microfarads. Accordingly, we see that the capacity, as deduced from the mean calculated condenser currents and the observed pressures at the ends of the mains, comes out a little low compared with the measured steady value; but the speeds and pressures were hardly observed with sufficient accuracy to make a closer agreement very likely, and the condenser current values are probably affected by some errors. It may be observed that the effect of a small but definite inductance in the fine-wire circuit of the transformers at the step-up end existing unannulled at full load would be to lower the condenser currents, and hence to lower the calculated capacity. I think it is pretty clear that what may be called the normal condenser current of the 11·5 statute miles of the trunk mains is about 14 or 16 ampères under a working pressure of 10,000 volts at the step-up end of the main, and at a frequency of about 67 for the circuit. This is what is generally observed.

On one occasion, when the writer was engaged with Mr. Ferranti in testing the trunk mains, we had a similar arrangement of the system to that above described—viz., a length of 11·5 statute miles of trunk main looped in London through two step-down and step-up transformers in parallel, and a similar set of transformers at Deptford.

Two 100 candle-power lamps were put on the far end of the system at Deptford, just to give indication of a current flowing through the system, otherwise there was no load. When the dynamos were excited so as to give 2,500 volts on the primary side of the step-up transformers, and this raised to 10,000 volts in the mains, we found a current of about 64 ampères going out of the dynamo at 2,500 volts. This would correspond to 16 ampères or so in the trunk mains. The actual working current at this time was merely the magnetising current of the step-down transformers and the normal current required for the lamps. Hence this experiment agreed in showing that the normal condenser current of the trunk mains at 10,000 volts and a frequency of 67 is about 1·4 ampères per mile run of the cable.

19. Let us next examine how far the observations taken with no load on the secondaries of the step-down transformers agrees with the foregoing. In this case we restrict our view to the last eight observations recorded in Table I. The numbers in column IV. give us at once the condenser current of the cable, because there is no sensible current flowing out of the cable except the negligible magnetising current of the transformers.

TABLE IV.

Condenser current, I, in ampères.	Mean potential difference of condenser surfaces of the cable, in volts.	Calculated capacity for the whole length in microfarads.
11	9,885	2·8
11	9,985	2·8
10	7,295	3·4
5	5,200	2·4
9	5,500	4·1
9	5,900	3·8
10	7,920	3·1
12	9,395	3·2

The variation in the values of the capacity shows that the measurements of the condenser currents are probably affected by considerable errors; and this is likely, seeing that the ammeters on the end of the trunk main would not read with sufficient accuracy to detect a difference of one or two ampères at these low readings. Hence all we can say is, that the mean capacity of the cable as deduced from the observations at no load—viz., 3·3 microfarads—is not extravagantly different from that obtained by observations at full load.

If we take one of the observations at half load—say No. 10 in Table I.—we arrive at the same result. For the ingoing and outgoing currents in the trunk main are then 22 and 17 ampères, and the difference of their squares is 14, which is probably nearly the condenser current in this case; and the mean potential difference of the surfaces of the cable is 10,560 volts; and hence, as before, the capacity comes out 3·3 microfarads for the whole length. Hence all the observations agree in giving a capacity of from 3·3 to 3·6 microfarads for the total cable in use. It may well be questioned whether for this paraffined paper dielectric the capacity as determined by a prolonged charge and discharge gives a value which is correctly expressive of the true working capacity of the cable under rapid alternations of charge. It must be remembered that paraffined paper presents usually a considerable absorption effect, and the value of 4 microfarads for the 11·5 miles, obtained by the usual ballistic galvanometer method, may be, and perhaps is, a value which is higher than that which correctly expresses the true working capacity of the cable under rapidly reversed electric stresses. It is important to have this point investigated for the dielectrics in use in the manufacture of types of concentric cables now employed.

20. Passing to the examination of other points indicated by the observations in Table I., we see that the mean potential difference of the two conductors of the cable is always greater than four times the dynamo terminal pressure as given in column IV. That is to say, these figures show that the pressure in the trunk main at the dynamo end is always greater than would be the pressure at the terminals of the step-up transformers if the trunk main were disconnected. This may be said to be the fundamental phenomena which has been much dis-described and misunderstood. The values of the pressures as read at the dynamo terminals and at the two ends of the trunk mains show that whenever the system is loaded, and there is a fairly heavy load, there is a fall of pressure down the cable, as there should be; although the actual figures seem to show that this fall of pressure is not quite equal in value to the product of the values of the true resistance of the cable and the current flowing through it. Those cases in which the figures in Table I. seem to show a rise of pressure along the main cannot be accepted as representing the actual facts. When the cable is relieved of all working current, and only traversed by a condenser current, the figures show that the cable is either all at one pressure all along, or else that there may be a slight rise from the step-up end to the step-down end of the cable. I think, however, that there is no good evidence of this rise of pressure from end to end of the cable when not loaded with external load. The chief fact is that, whereas the step-up transformers would, if existing alone, raise the dynamo pressure fourfold, we find that when the cable is heavily loaded the mean potential difference of the conductors exceeds four times the dynamo terminal pressure by something like 5 per cent.; and, when the external load is removed, that excess pressure more nearly amounts to about 10 or 15 per cent.

The general fact is quite in accordance with the foregoing theory. When the step-up transformers are heavily loaded, the inductance of their secondary circuits is practically annulled or very much reduced; when they are lightly loaded, it is at once increased. We have seen, in discussing the clock-diagram of electromotive forces as applied to this condenser problem, that the increase in pressure which takes place is always an evidence of the presence of inductance in the charging circuit, and that this rise of pressure will augment with increase of inductance in the line or in the step-up transformer. We are unable to test how far the general rise of pressure is in accordance with the foregoing theory, because we have no means of measuring the true mean inductance of the secondary, or high pressure, side of the step-up transformers. The presence of capacity in the line always keeps down the inductance of the transformer, because it compels a rather large current to flow into it from the dynamo, even when the work current flowing out of the cable is zero, or nothing more than the magnetising current of the step-down transformers.

21. In the foregoing paragraphs no attempt has been made to enter into a discussion of the physical *modus operandi* of these condenser effects. We can easily construct, as has been frequently done, mechanical analogies, in which the elastic yielding of a spring and the inertia of a heavy body take the place of the capacity and inductance in the electric system. It is possible, however, to over-rate the value of this mechanical parallel. It is probable that the actual physical operations taking place to produce these electrical effects are not adequately represented by a mechanical simile in which the inertia-like aspect of self-induction is exclusively regarded, although, of course, such mental representations have their use. Too much hypothesis is often as bad as too little in seeking to connect together observed facts and fundamental principles. We may regard a condenser, when subjected to periodic currents, as a non-dissipative impedance, if the term may be allowed, having also a negative self-induction. A condenser allows a flux of electricity to take place backwards and forwards through its dielectric, and, as far as alternating currents are concerned, it may be said to have a conductivity for electricity.

A condenser of capacity C, when traversed by periodic condenser currents of frequency n, acts in any circuit as equivalent to an impedance of magnitude $\frac{1}{\mathrm{C}\,p}$. It also acts as if it had a negative inductance equal to $\frac{1}{C p^2}$, p, as usual, standing for $2 \pi n$. By a negative inductance $\frac{1}{C p^2}$ must be understood a power of nullifying positive inductance in a conductor in series with the condenser, numerically to the amount of $\frac{1}{C p^2}$ henries. Suppose, then, that a condenser of capacity, C, is placed in series with an inductive resistance of inductance, L, and resistance, R, and a periodic P.D. equal to V_0 permitted to act on the two in series. The resultant inductance of the whole circuit is $L - \frac{1}{C p^2}$, and the resultant impedance is

$$\sqrt{R^2 + \left(L - \frac{1}{C\ p^2}\right)^2 p^2}.$$

Hence the current through the condenser is equal to

$$\frac{V_0}{\sqrt{R^2 + \left(L - \frac{1}{C\ p^2}\right)^2 p^2}}.$$

If the potential difference of the two sides of the condenser is called V_1, and the equivalent impedance of the condenser is $\frac{1}{C\ p}$, we may consider that the value of V_1 is obtained by taking the product of this so-called impedance of the condenser, $\frac{1}{C\ p}$, and the value of the current flowing through it. Hence we have,

$$V_1 = \frac{V_0}{\sqrt{R^2 + \left(L - \frac{1}{C\ p^2}\right)^2 p^2}} \frac{1}{C\ p};$$

but this is the same expression as that deduced before, for the ratio of V_1 and V_0. This is not to be considered as a demonstration of the equation, but only as showing how it may be regarded as being built up on the assumption that a condenser behaves towards alternating currents as an impedance causing fall of potential in a current passing through it, and capable of nullifying inductance in a circuit connected in series with it; and that such a view leads to an equation from which it is immediately seen that under some conditions V_1 must be greater than V_0.

22. Reference has been made recently in a paper read by Major Cardew to the difference of electric condition as regards potential above the earth which will exist between two insulated conductors one of which entirely encloses the other, and which have different capacities, when they are connected to the terminals of an insulated transformer or alternator. In the case of a concentric cable the two copper members of which are insulated from each other, and the outer one insulated from a metallic sheath connected to earth, we have two insulated conductors, the interior one having capacity with reference to the outer, but not with reference to the earth, and the outer one having capacity both with reference to the inner and also with respect to the earth. This last capacity is generally, in cables as actually made, very much greater than the former.

In the case of the Ferranti trunk mains, the inner-to-outer capacity is, as we have seen, about one-third of a microfarad per mile run of the cable. Calculating from the measured dimensions, and from the specific inductive capacity of the insulating material as deduced from the inner-to-outer capacity, the magnitude of the outer-to-earth capacity I find to be about ten times greater, or more than three microfarads per mile. It follows immediately, from elementary principles, that the two insulated members of such a concentric cable will, when connected respectively to the terminals of an insulated transformer or dynamo, always be brought into such a condition that the outer member is at zero-potential as regards the earth, and that the full difference of potential which the transformer or dynamo is capable of making will subsist between the outer and inner member of the cable. This is true only when the outer member entirely encloses the inner member; but it is also true that when the two conductors have different capacities, by reason of position or form, there will be an electrical inequality between them, in that the difference of potential between each conductor and the earth will not be the same. The conductor which has the larger capacity will have the lesser potential with respect to earth, provided always that both conductors attached to the poles of the generator or transformer are insulated throughout their length.

23. The condenser effect we have been considering, and in particular the alteration of the change of ratio of a transformer which takes place when its secondary circuit is connected to a conductor system having a certain capacity in relation to the inductance of that secondary circuit, is found to operate in many curious ways in the practical use of such combinations. For instance, if a pair of alternators separately excited are working in parallel on an omnibus main leading to a conductor system of no sensible capacity, then we know very well that if the dynamos are synchronised, and contributing equally to the outgoing current, the method adopted to take one dynamo out of circuit would be to lower its exciting current, and when its outgoing current fell to zero to sever its connection with the omnibus main. If, however, the alternators are working through step-up transformers, and into a conductor system consisting of concentric cable, it is found by experience that the exciting current of the dynamo to be taken out must be raised, and not lowered, in order to bring it into a condition in which it can be cut off from the omnibus main without dangerous sparking at the switch; and, conversely, in putting it into parallel the incoming alternator has to be excited to a lower electromotive force than is necessary to maintain the standard P.D. at the terminals of the step-up transformer before putting it into connection with the omnibus main. This is obviously due to the fact that the change ratio of the step-up transformer is altered by the very act of putting it into connection with the conductor system, and hence the excitation of the alternator at the moment of making or breaking connection with the main must be such as will bring the P.D. of the free secondary terminals of the step-up transformer to a value equal to the P.D. of the two points on the conductor having capacity to which they are about to be connected, or from which they have just been severed; and when the connection of the alternator is made, the excitation can be altered to divide the load on the machines properly. This, of course, would not be the case if high tension alternators of very small inductance were set to work in parallel on such a concentric conductor system. In this case the condenser effect is practically nothing, and the behaviour of the machines on going into or out of parallel would present nothing unusual.

24. In the cases briefly discussed above, the cables, whether concentric or simple, have been found to act as single condensers substituted for them would act; and in the experiments described no progressive rise of pressure from one end to the other of a cable possessing capacity was found to exist.

It is, however, quite possible for self-induction, resistance, and capacity to be so combined together in one conductor that the action of an impressed periodic electromotive force at one end will create a progressive rise of mean pressure along the cable when the far end is insulated. The complete theory of such effect is rather too long to discuss here. The propagation of a simple periodic current and the action of a simple periodic electromotive force upon a concentric cable has been very fully discussed by Mr. Oliver Heaviside in an able series of papers on "The Self-Induction of Wires," published in the *Philosophical Magazine* for 1886 and 1887. A very brief summary of the results is all that can be given here; but those desirous of further information may be particularly referred to *Philosophical Magazine*, vol. xxiii., January, 1887, page 18, in which paper Mr. Heaviside deals with the problem which is particularly the practical one, viz., a concentric cable having at one end a transmitting apparatus, such as a telephone, alternator, or a step-up transformer, and at the other a receiving instrument, such as another telephone or a step-down transformer.

We have, then, a sending instrument having resistance and inductance; a cable having resistance, capacity, and inductance; and a receiver having also resistance and inductance. Given the electromotive force in the transmitter, the problem is to find the current in the receiver.

Consider, first, a very long concentric cable having inductance, L, resistance, R, and capacity, C, all per unit of length. Fix attention upon a small length of the cable, δx, and suppose that the current flowing into this element at any instant is i, and the current flowing out of it is $i - \delta i$ when some electromotive force acts at one end of the cable. Also, let v be the potential of the inner conductor at the one end of the element of length, δx, and $v - \delta v$ be the potential at the other end; then the current, i, at any instant, t, is determined from the fundamental equation,

$$L \delta x \frac{d i}{d t} + R \delta x i = \delta v \qquad (33)$$

and the current and potential are connected by another relation,

$$\frac{d i}{d x} = C \frac{d v}{d t} \qquad (34)$$

because the current flowing out of the element of length is less than the current flowing into the element by the condenser current taken up in the element.

Differentiating (34), and substituting in (33), we arrive easily at the equation,

$$L C \frac{d^2 v}{d t^2} + R C \frac{d v}{d t} = \frac{d^2 v}{d x^2} \qquad (35)$$

This differential equation gives us the means of determining the potential, v, at any time and place in the cable.

Let v_0 be the electromotive force at the origin or the end of the cable at which the dynamo or electromotor is applied, and let V_0 be its maximum value—such, that

$$v_0 = V_0 \sin p t:$$

then, if the cable is infinite in length, the solution of the equation (35) can be obtained, and the potential, v, at any distance, x, from the origin, and any time, is easily shown to be given by

$$v = V_0 e^{-P x} \sin (p t - Q x),$$

where the quantities, P and Q, are—

$$P = \pm \left\{\frac{p C}{2}\left(\sqrt{R^2 + p^2 L^2} - L p\right)\right\}^{\frac{1}{2}},$$

and

$$Q = \pm \left\{\frac{p C}{2}\left(\sqrt{R^2 + p^2 L^2} + L p\right)\right\}^{\frac{1}{2}}.$$

For the Ferranti trunk mains the values of these quantities have been calculated in Section 14.

If the cable is not infinite in length, but has a finite length, l, then two cases may be considered—(i.) when the cable is short-circuited at the far end, and (ii.) when its two members are insulated or open-circuited at the far end.

Taking the first case of a concentric cable of length, l, short-circuited at the far end, and attached to an alternator of negligible inductance and resistance at the other, Mr. Heaviside has shown how the potential at any distance, x, from the machine can be obtained, and also the current flowing through an ammeter placed at any point in the cable. If V_0 is the maximum value of the periodic electromotive force applied at the dynamo end, and v is the potential at any time, t, and any distance, x, from the dynamo end, then he gives the value of v as

$$v = V_0 e^{-Px}\sin(pt - Qx) + V_0 \frac{e^{Px}\sin(pt + \theta_2 + Qx)}{e^{Pl}(e^{2Pl} + e^{-2Pl} - 2\cos 2Ql)^{\frac{1}{2}}} - V_0 \frac{e^{-Px}\sin(pt + \theta_2 - Qx)}{e^{Pl}(e^{Pl} + e^{-2Pl} - 2\cos 2Ql)^{\frac{1}{2}}}$$

(see *Phil. Mag.*, vol. xxii., September, 1886, p. 284).

It can be shown from the above that the ratio of the maximum value, V, of the potential at any distance, x, from the origin, to the potential at the origin, V_0, is given by the relation,

$$\left(\frac{V}{V_0}\right)^2 = \frac{e^{2P(l-x)} + e^{-2P(l-x)} - 2\cos 2Q(l-x)}{e^{2Pl} + e^{-2Pl} - 2\cos 2Ql} \quad (36)$$

In the above equations P and Q stand for the functions of resistance, inductance, and capacity given above in Section 14, and e is the Naperian base.

The equation (36) enables the pressure at any point in the cable, as given by a voltmeter, to be predetermined from the pressure at the origin. The current flowing through a low-resistance ammeter placed at any point in the cable can also be deduced from the equation (36), and its maximum value, I, is shown by Mr. Heaviside to be given by the equation,

$$I^2 = \frac{V_0^2 C p}{\sqrt{R^2 + p^2 l^2}} \frac{e^{2P(l-x)} + e^{-2P(l-x)} + 2\cos 2Q(l-x)}{e^{2Pl} + e^{-2Pl} - 2\cos 2Ql} \quad (37)$$

This gives us the value of the dynamometer reading at any point in the cable. It shows us that if l is great enough the current flowing through an ammeter placed at the distant end of the cable would be zero.

Suppose, next, that the distant end of the cable is open-circuited, and that an electromotive force, of which the maximum value is V_0, acts at the home end. It is then possible to prove that under these circumstances the ratio of the maximum value, V, of the potential at any distance, x, from the origin, to the maximum value of the potential at the origin, is given by the equation,

$$\left(\frac{V}{V_0}\right)^2 = \frac{e^{2P(l-x)} + e^{-2P(l-x)} + 2\cos 2Q(l-x)}{e^{2Pl} + e^{-2Pl} + 2\cos 2Ql} \quad (38)$$

If $x = l$—that is, if we consider the potential at the far end, the numerator of the right-hand side, becomes equal to 4, and hence if the denominator is numerically less than 4 for any given cable—it indicates that a progressive rise in pressure along such cable will take place from the machine end to the free or insulated end.

In a very able paper in the *Philosophical Magazine* for January, 1887, p. 21, Mr. Heaviside has attacked the general problem of calculating the current flowing through a transformer at the far end of a concentric cable when an alternator or transformer giving a periodic electromotive force of maximum V_0 is placed at the other. The paper is not an easy one to read, and was probably still harder to write. Some of the general results are, very briefly, as follows:—If L_0 and R_0 are the total inductance and resistance of the transmitter, whether alternator or transformer, and L_1 and R_1 the same quantities for the receiver, and L, R, and C the inductance, resistance, and capacity per unit of length of the cable, and V_0 the maximum value of the impressed electromotive force at the transmitter, and C_0 the maximum value of the current through the receiver, then

$$C_0 = 2V_0 \frac{Cp}{(R^2 + p^2 L^2)^{\frac{1}{2}}} \left[G_1 G_0 e^{-2Pl} + H_1 H_0 e^{-2Pl} - 2(G_1 G_0 H_1 H_0)^{\frac{1}{2}} \cos 2(Ql + \theta) \right]^{-\frac{1}{2}}$$

where G_1, G_0, H_1, H_0, and θ are complicated functions of the resistances and inductances of the receiver and transmitter, and which have the values,

$$G_0 = 1 + (P^2 + Q^2)\left(\frac{I_0}{I}\right)^2 + (2PR + 2QpL)R_0 + (2PLp^2 - 2QpR)L_0;$$

$$H = 1 + (P^2 + Q^2)\left(\frac{I_0}{I}\right)^2 + (2PR + 2QpL)R_0 - (2PLp^2 - 2QpR)L_0;$$

and similarly for H_1 and G_1.

I_0, I, and I_1 are the impedances of the transmitter, cable, and receiver; and the quantities P and Q have the values given in Section 14.

The quantity θ is an angle which is determined from the expression,

$$\tan 2\theta = \frac{2(Ab - aB)}{A^2 + B^2 - (a^2 - b^2)},$$

where

$$Ab - aB = (R_0 + R_1)(RQ - LpP) + (L_0 + L_1)p(RP + LpQ) - (R_0 I_1^2 + R_1 I_0^2)CpP - (L_0 I_1^2 + L_1 I_0^2)p^2 CQ;$$

$$A^2 + B^2 = I^2 + C^2 p^2 I_0^2 I_1^2 + 2(R_0 R_1 - L_0 L_1 p^2)LCp^2 - 2(R_1 L_0 + R_0 L_1)p^2 RC;$$

$$a^2 + b^2 = (P^2 + Q^2)[(R_0 + R_1)^2 + p^2(L_0 + L_1)^2].$$

The question whether the mean pressure at the receiver is greater than the mean pressure at the sending end, or less, will in general depend upon the sign of $\tan 2\theta$.

The quantities, G_0 and H_0, become equal to unity when the inductance and resistance of the sending instrument are zero or very small.

The practical deduction which may be made from the above investigation is, that when the alternator at the sending end has very small resistance and inductance, the pressure at the receiving end of the cable will be less than the pressure at the transmitting end, for almost any cases which occur in practice; but this is not always the case when the transmitting instrument has a sensible inductance. We may then have conditions under which there is a progressive rise of pressure from the sending to the receiving end.

The time at disposal has not permitted me to do more than sketch out the general results of such investigations as have been made on the propagation of periodic currents through conductors having sensible capacity and inductance. These investigations need to be brought into further comparisons with the results of experience, in order that we may see how far they agree with observed facts, and how far they can be trusted as a guide in predicting the results of the application of known electromotive forces to conductor systems in which the capacity and inductance can be predetermined.

May 14th, 1891.

DISCUSSION (AUTHORISED ABSTRACT).

IN opening the discussion, Mr. SWINBURNE said he was particularly interested in the subject dealt with in the paper, for he considered it a most important one, and believed he himself was the first to suggest the true explanation of the phenomenon known as the Ferranti effect. When the effect was first observed it was looked upon as peculiar, and various authorities were exercised in finding an explanation. In December last, when he read a paper on alternate current condensers before the Physical Society, no authoritative statement as to what actually occurred had been published, but he took the conditions and worked backwards to see what the effect ought to be. He then found that putting a condenser on the secondary mains would increase the pressure, and explained the rise by the action of the "leading" condenser current on the magnets of the alternator. Whether the rise might be said to be due to armature reactions or to self-induction, was chiefly a question as to what was meant by self-induction. Several persons had attributed the "Ferranti effect" to the transformers, since the rise did not occur when the transformers were not interposed between the alternator and the trunk mains. This difference he showed to be caused by the condenser current in the alternator being four times greater when the transformers were on, and, in addition, the field magnets were only about one-fourth as strong, so that they were more easily influenced by the condenser current. He himself thought any rise due to the transformer would be small, but Dr. Fleming had found it fairly large. This was probably owing to the comparative smallness of the transformers used, for in very large transformers, such as he assumed were employed, the magnetic leakage to which he (Mr. Swinburne) attributed any rise caused by the transformer was relatively small. He ventured to think that Dr. Fleming had made a mistake in imagining the self-induction of the primary of a transformer an important factor in the phenomenon, for it could only act as a choking coil, in consequence of the magnetic leakage which existed. Part of the increased pressure was due to the "drop" in the transformer, and in designing transformers this drop should always be determined and allowed for. After giving a formula expressing the drop in open circuit transformers, he said that Prof. Ayrton had found that there was a rise of pressure due to the transformer, and had also stated that a rise occurred in the mains themselves; this he (Mr. Swinburne) had shown to be impossible. He hoped Dr. Fleming would go into the subject of transformers more fully, taking the waste field into account. Unfortunately, this leakage was at present considerable, but he thought it would soon be reduced.

Prof. AYRTON said he took great interest in Dr. Fleming's paper, because it confirmed many results brought forward by Dr. Sumpner and himself in a paper recently read before the Physical Society. Referring to paragraph 6 of Dr. Fleming's paper, he said that the general statements about Mr. Blakesley's conclusions and those of the author were rather confusing, for Mr. Blakesley's results were only applicable to shunted condensers, whereas those of Dr. Fleming referred to unshunted condensers. On slip 4, in treating of resonance, the author, he said, concluded that there was only a narrow range of capacity within which the pressure at the condenser may be much greater than that at the machine. This conclusion resulted from his having chosen a coil having a resistance of only 10 ohms, and a very large self induction of 200 secohms (henries). As a matter of fact, resonance effects spread over a large range, and in practice it was impossible to get a coil with such a large time-constant as Dr. Fleming had imagined. The pressure at the condenser could therefore never be 100 or a 1,000 times that at the alternator, 5 or 10 times being about the practical limit. The experiments made by Messrs. Siemens Brothers were very interesting, and distinctly proved that the ratio of transformation of a converter varied with capacity. No doubt Mr. Swinburne would say it was all due to leakage, but nevertheless, the fact that the change existed was certain. In some experiments which Dr. Sumpner and himself had brought before the Physical Society, a change of 11 per cent. was observed when the ratio of transformation was only 2, and it was then pointed out that with larger ratios, the changes would be greater. In the case of the Siemens transformer, the ratio increased 32 per cent. Referring to the mathematical equation, No. 31 in the paper, viz.:

$$I = \frac{Cp}{\sqrt{(1 - CLp^2)^2 + C^2 R^2 p^2}} V_0$$

he said the matter was greatly simplified by dividing both numerator and denominator by Cp, thereby obtaining

$$I = \frac{V_0}{\sqrt{\left(\frac{1}{Cp} - Lp\right)^2 + R^2}}.$$

The numerator then became an *electromotive force*, and the denominator represented *ohms*, for since R was resistance in ohms $\left(\frac{1}{C p} - L p\right)$ must also be of the order ohms, otherwise they could not be added together. On slip 17, Dr. Fleming had written the equation in practically the same way, but did not prove the equation there given. The proof of (31) was greatly simplified by taking the current as the given element, instead of the pressure. For assuming that $i = I \sin p t$, where I is the maximum value of the current, then in a circuit having resistance, R, and inductance, L, in series with a condenser of capacity, C, the pressure between the ends at any instant was given by

$$V = R i + L \frac{d i}{d t} + \frac{1}{C} \int i d t$$

$$\therefore \quad = R I \sin p t + L p I \cos p t + \frac{I}{C} \int \sin p t . d t$$

$$\text{Hence } V = R I \sin p t + \left(L p - \frac{1}{C p}\right) I \cos p t$$

The form of this expression showed that the phases of the two terms on the right hand side were in quadrature, hence the maximum value of V could be got by taking the square root of the sum of the squares of the coefficients, and equation 31 followed immediately. This method had also the advantage of introducing no differential equations of the second order, and was very convenient for teaching purposes. Referring to the so-called Ferranti effect, he enquired whether the pressure at the dynamo terminals was observed before the trunk mains were attached. He also took the opportunity of pointing out a mistake he had made in a diagram published in the *Electrician* on January 2nd, 1891. In this figure the connections were shown wrong, and hence gave the impression that a rise occurred in the part of the circuit representing the mains themselves. Although no rise had been observed, Mr. O. Heaviside had shown that under certain conditions such a rise would take place. He did not think Mr. Swinburne was correct in stating that he (Prof. Ayrton) had ever said there was a rise in the Deptford mains. What he did say was that a voltmeter operated from the distributing mains at London read 100 volts, whilst a similar one actuated from the primary at Deptford read 80 volts; and this statement was now borne out by the figures published by Dr. Fleming.

Mr. Evershed thought neither Mr. Swinburne nor Prof. Ayrton had expressed the true feeling of the meeting towards Dr. Fleming for bringing forward such a valuable paper. Although Mr. Swinburne had conceived the true explanation of why a rise of pressure should occur when the Ferranti trunk mains were connected to the transformers, he had not made himself clear, and his explanation was not complete, for the cause of the change in the ratio of transformation had not been given. The phenomena were, he thought, best considered separately. Taking the case of the general rise of pressure in both circuits by putting on a condenser, he pointed out that when the E.M.F. of the alternator was a maximum the condenser was fully charged and no current passing into it, whereas the condenser current was a maximum when the E.M.F. was zero. Now, the E.M.F. of the alternator being zero when the armature coils are directly opposite the magnet poles, the condenser current attained its maximum at the instant when the coils were in a favourable position for influencing the fields. A little consideration, he said, showed that this current would strengthen the fields, and hence cause a greater E.M.F., and a rise would, therefore, be observed in both circuits. To explain the change in the ratio of transformation, he considered a 1 to 1 transformer having considerable magnetic leakage between the two coils. Just as was shown in the previous case, when a condenser was put across the secondary mains the condenser current would be a maximum when the secondary E.M.F. was zero. But zero E.M.F. meant maximum induction in the iron, hence the condenser current being in step with the induction would increase the induction in the iron; but, owing to leakage, this increase would affect the E.M.F. of the secondary more than that of the primary, and hence change the ratio of transformation. It was, therefore, quite possible to neutralise the "drop" in transformers by putting on condensers, and had Mr. Ferranti designed his transformers to give a greater drop, he might have arranged so that when working on the trunk mains the "drop," instead of being converted into a rise, was exactly compensated. Referring to the method of writing equation (31) mentioned by Prof. Ayrton, he protested against the terms other than R being reckoned in ohms; for passing currents through ohms meant generation of heat, whereas no self-induction wasted energy. In his opinion, the terms were of the nature of E.M.F., and ought to be called E.M.Fs. rather than resistances.

Prof. Ayrton asked Dr. Fleming to what cause he attributed the fact that the observed condenser currents given in section 12 were considerably greater than those calculated. In some experiments made by Dr. Sumpner and himself on the same subject they had measured the current and calculated the capacity, and found the latter to agree very closely with that determined by ordinary ballistic methods.

Mr. Swinburne suggested that the increased capacity might be due to the "soaking in" which he had mentioned in his paper on alternate current condensers read before the Physical Society.

Mr. Addenbrooke said the soaking in of the charge might affect the capacity in a way similar to that in which the insulation resistance of a cable varied with the time the current was kept on. In giving the insulation resistance of any specimen it should be distinctly stated under what conditions the tests were made. Moreover, the resistance of a cable increased for a long time after it was manufactured, and almost any desired insulation resistance could be obtained by waiting long enough. In alternating current work the current was, he said, "on" for about $\frac{1}{100}$th of a second, and the resistance for such currents might be quite different to that found by steady current tests. Information as to the properties of paper insulated cables, under various conditions, would be very valuable at the present time.

Mr. Preece, replying to Prof. Ayrton's statement that a coil having a time constant of 20 seconds could not be made, pointed out that Faraday's coil at the Royal Institution required two minutes for the current to attain its maximum value. A submarine cable when coiled in its tank had also an enormous self-induction, as was proved by a test made by Mr. Edison at the Telegraph Construction and Maintenance Company's works, when he found that a telegraphic "dot" put in at one end of the cable came out 27 inches long at the other.

Prof. Ayrton could not understand how self-induction could lengthen the dot, but capacity might do so.

ON SOME POINTS CONNECTED WITH MAINS FOR ELECTRIC LIGHTING.*

By William Henry Preece, F.R.S., Past-President.

1. I do not purpose in the following paper to describe the mechanical details of the various systems of mains adopted in different places to transfer and distribute electrical energy. These, most of us can see for ourselves by personal inspection in the various works now in progress in London, or can read about at our leisure, in the numerous papers that have been recently printed in the technical periodicals and in the Journal of our Institution. My object is to extol the "sweet simplicity" of the two-wire system, the practical security of concentric mains, and the unquestionable economy of the high pressure principle. At the same time, I do not want to be considered an advocate of any one particular method. Engineering works must necessarily be considered a species of compromise. Conditions vary in different localities; difficulties arise in the most unexpected quarters; different ways of surmounting obstacles occur to different minds. What is good for one place need not necessarily be good for another. The independent engineer must keep his mind open; he must master his requirements; he must give every plan his consideration, and choose his best agents, despite the tyranny of the patent laws and the susceptibility of inventors. He must, however, be just, and see that merit is rewarded and claims respected.

2. I do not intend to discuss overhead wires. I consider them, for high pressure electric light circuits, an abomination, especially as it is easy to show that ultimate economy is in favour of the underground system. It is only the first capital expenditure that favours overground mains; safety, freedom from accident, ease of repair, and renewals are all the other way.

3. Broadly, the different underground systems in use may be classed into those which are *fixed*, and those which are *movable*.

As a type of the first, I will instance the Ferranti concentric mains, that are buried solidly in the roadways, embedded in asphalte in wooden troughs, and which are inaccessible except by excavation; and as an example of the second, I will take the ordinary telegraphic method of burying cast iron pipes, with occasional boxes, in and out of which, cables new and old can be drawn at pleasure, and where the conductors are always accessible for the rapid removal of incipient faults should they develop themselves, and removable for enlargement should the system grow.

4. Again, we must divide the systems into *high* and *low pressure*, for under these two heads we have to consider not only the all-important questions of insulation and of finance, but those of security to person and to property. The line of demarcation between high and low pressure has been defined by the Board of Trade to be 300 volts; but in what follows, whenever *high pressure* is mentioned about 2,000 volts is meant, and *low pressure* implies about 100 volts. There is one case only in this country where *extra high pressure* is used, and that is by Mr. Ferranti, whose adoption of 10,000 volts is regarded by so many with fear and horror. This voltage is, however, going to be exceeded this summer by the Exhibition authorities at Frankfort, who are going to draw 300 horse-power from the river Neckar, at Lauffen, 112 miles away, by a pressure of 27,000 volts.

5. The only limit to the use of extra high pressures, or to the voltage employed, is the efficiency, economy, and durability of insulating materials.

First and cheapest on the list is *air*, which, when dry, is the most perfect insulator known—its specific resistance being, in fact, immeasurable—which has the lowest specific inductivity, and therefore is taken as unity, but which cannot resist electric stress, and through which the sparking distance has a very poor figure of merit. The breakdown stress, or sparking distance, of dry air at ordinary atmospheric pressures may be taken to be for—

Direct currents	9,200 volts per centimetre;
Periodic alternating currents	6,000 " "

between a disc and point.

Air is, moreover, hygroscopic, and very variable in its qualities; but there is no evidence that the variation of its saturation point affects its resistance or its inductivity, excepting that it tends to coat with moisture, glass, porcelain, and other insulating supports, which are essential to keep up metallic conductors in position when it is used as an insulator, if their temperature falls below that of the air. The use of air was inaugurated by Mr. Crompton in Kensington, and his example has been followed by Latimer Clark, Muirhead & Co., in

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* Paper read 7th May, 1891.

St. James's, by Prof. Kennedy in Westminster, and by Prof. Robinson in St. Pancras. It has also been followed in Paris and in Germany.

6. *Gutta-percha* has been used almost exclusively for submarine cables, and for telegraphic underground wires in Europe; but owing to its scarcity and its high price it is rapidly being replaced by other materials, and, excepting in Paddington (Great Western Railway), where it was laid down by the Telegraph Construction Company, I do not know of its use for electric light purposes. It does not stand exposure to variations of temperature or of dryness. It is durable only in water, and even if it were plentiful, it is doubtful if it were practical for electric light purposes.

7. *India-rubber* is more practical. Modern improvements in vulcanisation have brought it within the scope of the engineer and the range of finance. The addition of a small quantity of sulphur, subjected to high temperature, produces a new form of rubber, which makes not only an admirable insulator, but a waterproof, homogeneous, compact, and apparently durable compound. Our experience of this latter quality is, however, limited at present. The cables of this class manufactured by the Silvertown Company have justly acquired a high reputation, though several other firms are competing with them on equal merits. The weak point is in the jointing, which, unless properly done and thoroughly vulcanised, admits into the system numerous points of danger which, sooner or later, will occasion engineers in charge many minutes of anxiety and worry. Compound rubber cables are used exclusively by the Metropolitan Electric Supply Company and by the House-to-House Electric Light Company, for their mains distributing high-pressure alternating currents. I am assured by both companies that up to the present time not one single defect has developed itself in their mains.

8. *Bitumen* is a mineral product of a pitchy character, imported into this country principally from Trinidad. The late Lord Cochrane tried hard to introduce it as an insulating medium, but it remained for the enterprising firm of Callender to make it a real commercial commodity. When purified, refined, and vulcanised it makes, combined with some vegetable fibre like jute, a tough elastic coating, proving it to be an active competitor of compound rubber. When used in its crude state it forms a solid mass, in which the more refined "bittite" can be embedded in an immovable and apparently indestructible and unassailable bed.

9. There are various waxes—*paraffin*, *ozokerit*, and other hydrocarbons—which have a high specific resistance and a low specific inductivity, that have been much used; but the most practical use of these materials appears to be their combination with brown paper, which has been introduced by Mr. Ferranti in his Deptford mains.

10. The refuse of crude *petroleum*—that is, petroleum after all the spirits, illuminating and lubricating oils, and waxes have been distilled or expressed—a thick, heavy black mass, liquifiable under high temperature, but almost uninflammable, and eminently adapted to resist high temperatures—makes an admirable insulating compound of very high specific resistance and comparatively low specific inductivity. It is the material used by the Fowler-Waring Company, and destined to enjoy a profitable career.

11. *Heavy resin oil* is an admirable insulator, filling, when hot, all the pores of vegetable matter like jute and cotton immersed in it, excluding all air and moisture from the conductor, having a very high resistance and a very short sparking distance, but, above all, being viscid and movable, so that any puncture is at once filled up by its own mobility, so that any fault occasioned by piercing is instantaneously self-cured. Oil has such excellent merits that it has been proposed by Johnson and Phillips to bury in it high-pressure alternate-current transformers. Heavy oils discard water, owing to their density. They are inoxidisable, and therefore practically indestructible. Many failures in the use of oil as an insulator in the past have arisen from the use of oils of too low specific gravity.

12. There is one objection to most of these mineral hydrocarbons, viz., that they require to be encased in lead; but oil has this advantage—that it can be used in iron pipes in the method adopted by Brooks. Lead covering is expensive, and it adds seriously to the weight of the cable, so as to render more difficult its handling and drawing in and out. On the other hand, lead adds materially to the life of the cable. I have in my possession samples of lead-covered wire which was buried in 1844, and in which the conductor and insulating medium are now as perfect as when made. Lead, however, in some localities, especially in decaying vegetable matter, is itself attacked. When, however, properly protected, it ought to last for centuries. The lead used by the Romans to distribute water in Pompeii is still visible. Lead-covered cables are very largely used in America, Germany, and France, and their employment is rapidly extending in England.

13. All these materials, excepting air, are equally applicable for high and for low pressures: the thickness only has to be increased with the pressure; but we have yet to know what influence the rapid reversals of high pressure alternating currents have upon the molecular structure of the material. The difference in the striking distance in air shows that the stresses in the two cases of direct and alternating currents are very different. Time alone will give us the experience we want as to the effect of these stresses on the texture of the dielectric used. It is this absence of experience that causes so much want of confidence in the use of extra high pressures.

14. The operation of Sir William Thomson's law, the relative economies of the two-wire, three-wire, and five-wire modes of distribution, the comparative cost of high and low pressure, have been so frequently discussed, and are so thoroughly well known, that they need no description here. Everyone will admit that as we increase the pressure driving the currents, we can diminish the size of the conductor; and although we have to increase the relative thickness of the insulating medium, the actual quantity used remains practically the same. Hence high pressure means great economy in copper. The future of electric lighting is a financial question; its practicability and efficiency are beyond doubt. The lion share of the capital necessary for the extension of electric lighting over a district is required for the mains and conductors; an important item in working expenses is in their maintenance. Hence this is now the field for the exercise of economy. If we can reduce the cost of distribution and its upkeep by 50 per cent., we should be able to supply light by electrical energy more cheaply than by gas. It is a pity that some of that redundant mental energy which is endeavouring to raise the efficiency of dynamos and transformers from 94 per cent. to 95 per cent. could not be transferred to the question of mains, where real advancement and true economy on a considerable scale are much more required.

In Liverpool, Birmingham, and Bradford, low pressure is distributed by the original and simple two-wire parallel system. In Kensington and Westminster low pressure is distributed by the three-wire plan. The London Electric Supply Company, the Metropolitan Company, and the House-to-House Company distribute their high pressure systems by two wires; but in Rome, where sub-stations are used, the distribution of low pressure is by three wires. In Germany distribution in some places is by five wires, and I have heard it mooted to distribute in Paris by six wires.

15. The points that determine the distribution of low pressure are fall of potential, and number of feeding points and distributing stations. We need not consider the heating of conductors. If we take care of the potentials, the waste will take care of itself.

One ton of copper of one square inch sectional area covers a length of 192·3 yards, and its resistance is ·0046 ω. Hence, a length of 220 yards weighs 1·13 tons, and its resistance is ·00527 ω. A pair of such mains will weigh 2·26 tons, and their resistance will be ·01054 ω. 1,000 ampères means, therefore, a loss of 10½ per cent. (and one kilowatt is wasted in every 43·4 yards), 500 ampères means a loss of 5¼ per cent., and 237 ampères means a loss of 2½ per cent., in such a circuit when the full load is supposed to be concentrated at the end. If we take a fall of potential of 2½ per cent. in each main, which is the recognised maximum waste at full load allowed to comply well with Thomson's law, it means 474 ampères delivered at 100 volts, or 1,600 8-candle-power lamps served. In fact, we may say that two mains of 1 square inch copper will serve 1,600 8-candle-power lamps at 220 yards distance; and this appears to be the commercial limit of the two-wire low pressure distribution. Of course, if we are content to admit a greater waste, this limit of distance can be extended, and the number of lamps to be served can be increased in the same ratio. The exact waste to be allowed is an economical question governed a good deal by the conditions of the problems, financially as well as engineering. Now, if we add another 100 volts at the point of supply, we can deliver the same energy for the same number of lamps with the same loss, at 880 yards; and for every additional 100 volts delivered, we can extend the distance to which the supply can be driven under similar conditions, as the square of the unit distance, 220 yards, for to maintain the same energy the current is *diminished* in the same ratio. Thus 2,050 volts will drive the energy required for 1,600 8-candle-power lamps 50 miles if we use mains of one square inch sectional area, and are satisfied to waste only 5 per cent. of the driving energy. Prof. John Hopkinson, F.R.S., showed how,* by the use of an intermediate third wire and two dynamos, we could use 200 volts with our present lamps, and therefore we could practically diminish for the same distance the weight of copper used by one-half, or we could make the same weight of copper serve double the distance. The third wire, however, diminishes the effective economy of the plan. Its practical commercial limit appears to be about half a mile; and its disadvantages to be more dynamos to work, and considerable complication to adjust and regulate the equilibrium of lamps on the circuit.

The five-wire system, which is in use in Germany, enables us to use 400 volts at the point of delivery; and this, again, enables us to extend our area of supply with the same weight of copper, to one mile, but with more dynamos, and with more regulation and balancing, and therefore with more complication.

There is no practical limit to the high-pressure system: 10,000 volts will drive energy from Deptford to London on two mains of one-quarter square inch section to serve 50,000 lamps; and 27,000 volts will drive 300 horse-power 112 miles, from Lauffen to Frankfort, on a conductor of ·06 square inch sectional area, *i.e.*, a No. 2 copper wire.

16. But we have to take into consideration the difficulties of the distribution.

On the two-wire system this means one central station for each effective area having a mean radius of 220 yards. On the three-wire system this area can be extended to a mean radius of one-half mile; the five-wire system extends the mean radius to one mile; but with the high-pressure system the area is practically unlimited in extent. When the mains and feeders are at high pressure, and the distribution at low pressure by two wires, we must contemplate *sub-stations* serving areas having a radius not exceeding 220 yards, if the lamps be uniformly scattered over the area and our waste energy is kept low.

A transformer sub-station is a very simple and cheap structure. It may be excavated underground, or be in a cellar or in a back yard. The instruments are stationary. They require no oiling, nor adjusting, nor handling, nor even tending. They can be buried in oil and suffer no deterioration. They are simple in construction, and should need no repair. Switches to throw them in and out of circuit may be automatic or manual, and can be operated from outside the transformer room, as is done in Rome.

17. The sub-station high-pressure system has been thoroughly worked out in Rome. Every nest of about 2,000 lamps is served from a sub-station containing a bank of 12 transformers, each of 7½ kilowatt capacity. Means are provided to cut transformers in and

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* John Hopkinson, Patent No. 3,576, July, 1882.

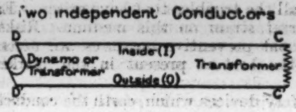
out as the load comes on and off. The great waste of the idle transformer is thus prevented, and by banking them in this way only half the total number of transformers is required. Moreover, it enables the most efficient transformers to be used, and always at full load. It is well known that the efficiency of a transformer increases with its size. Mr. Ferranti has already reached 100 kilowatts without reaching a limit to this law. Distribution by two wires on this limited scale is of the most economical and effective kind, and there is no complication of adjustment of current or regulation of pressure. Each sub-station serves, as a rule, in Rome, one block of buildings, so that generally the high-pressure mains alone are underground. The pressure is 2,400 volts. The distribution in Rome is by three wires—not, however, for any economical reason, but simply to allow arcs and glow lamps to work on the same network without interference and without waste. The counter electromotive force of the arc prevents arc lamps from being registered accurately on any of the existing meters, but the three-wire plan enables the arcs to be served separately from the glow-lamps. Arc lighting is in great request in Italy, especially for shop-lighting.

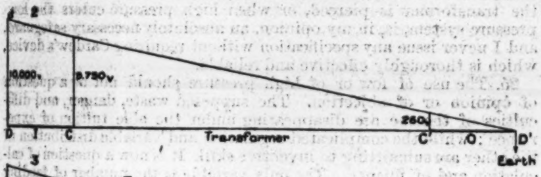
The chief difficulty the engineer has to encounter is to know his users and the extent and character of the supply. This is now generally guesswork. It is difficult to estimate the actual load factor. We have to take the gas supply as our criterion, and to judge of the probability of obtaining customers from the character of the residents and occupants of the district.

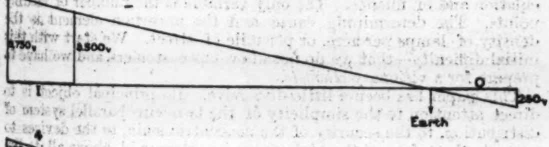
18. It is impossible to serve economically a wide and scattered district with a mean radius of over one mile by any other means than by high pressure, for we cannot multiply central stations without seriously increasing capital outlay and working expenses; unless, indeed, the density of supply be very great, as it is in some quarters in London and in some of our large provincial cities.

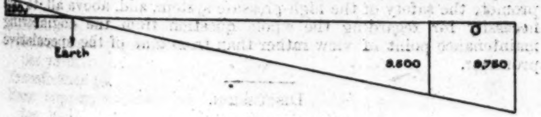
19. Let us assume that we have a wide and scattered district to serve, and that we are going to supply at high pressure, and to distribute by two wires from sub-stations: the problem we have to solve is, what shall be the character of the high pressure mains and feeders connecting the central station, or stations, and the sub-stations?—shall they be separate conductors or concentric cables? We will also assume that the weight of copper and quality of insulation is the same in each case, and that their prime cost is not materially different, although, as a matter of fact, for the same distance the concentric main, if made of the same materials, costs less than the two separate conductors.

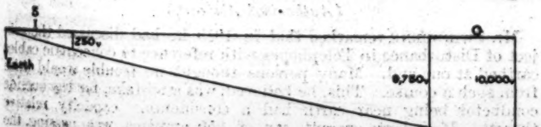
Two independent Conductors

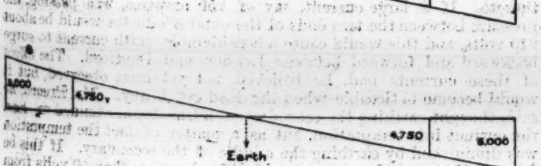








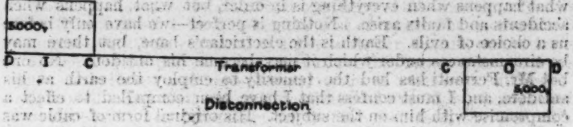




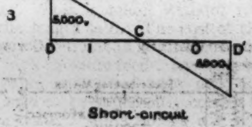
It is therefore a question of *adaptability*, *security*, and *freedom from disturbance*. To study these points, we want to know how the potentials are distributed on such conductors.

If we consider two independent conductors (fig. 1), lying side by side in the same pipe, or conduit, connecting the two poles of the dynamo, D and D', with the transformer, C C', and we call the *go* wire the *inside* (I) and the *return* wire the *outside* (O)—then, if we represent the effective resistances at any moment of the transformer by the straight D D' line (fig. 2), D C can represent the resistance of the inside conductor, C C' that of the transformer, and C D' that of the outside conductor. If the ordinate, D *d*, represents the positive pressure when at its maximum and the transformer on full load, then, if the pole, D', be connected with earth, the slope of the line will indicate the simultaneous pressure at any point of the circuit, and the difference between the ordinates will give the fall of potential between any two points; that is, there is a fall of 250 volts in each conductor, and if the circuit be carrying 50 ampères there will be a waste of 12,500 watts in each conductor. If the line, O, were in its proper position and direction alongside I, as in fig. 1, it would be seen that the difference of potentials between any contiguous points is everywhere 10,000 volts.

Now, if the earth be transferred from D' to the negative pole of the transformer, C', the pressure at the similar phase will rearrange itself as shown in fig. 3; and figs. 4 and 5 give the same information when the earth is consecutively fixed at the other pole of the transformer and dynamo. Fig. 6 shows the distribution when the centre of the transformer is to earth, or when there is no earth. It will be seen in each case that the fall of pressure remains the same; the difference between the potentials between the conductors remain the same; it is the sign and the difference of potential between each point and the earth that has altered. Fig. 7 shows the distribution when the transformer by some accident is disconnected, and fig. 8 when it is short circuited.



Disconnection

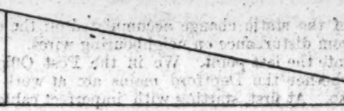


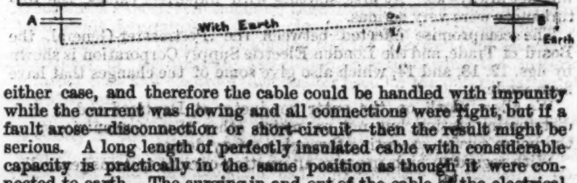
Short-circuit

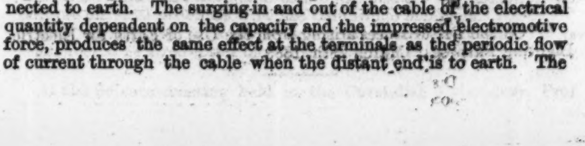
I have not considered the variations of potential due to the rise and fall of the currents, and I have ignored the dynamo—the potentials being those at its terminals. Frequency, inductance, impedance, besides capacity and resistance, enter to complicate matters and to deprive the graphical method of that simplicity which is shown by the figures. But Dr. Fleming has exhaustively dealt with this subject analytically and in a masterly manner.

20. Now Mr. Ferranti's mains are concentric, and their capacity must be taken into consideration. Fig. 9 show these capacities, that between the two conductors being ·35 microfarad per mile, and that between the outer tube and earth being 3 microfarads per mile. Figs. 10 and 11 show the distribution of pressures when the earth is on and off the pole of the dynamo. The remarkable fact comes out that whether the pole be to earth or not the difference of potential between the outer conductor and earth of a concentric cable is practically the same in each case. It does not exceed 250 volts in either case, and therefore the cable could be handled with impunity while the current was flowing and all connections were right, but if a fault arose—disconnection or short-circuit—then the result might be serious. A long length of perfectly insulated cable with considerable capacity is practically in the same position as though it were connected to earth. The surging in and out of the cable of the electrical quantity dependent on the capacity and the impressed electromotive force, produces the same effect at the terminals as the periodic flow of current through the cable when the distant end is to earth. The

Concentric Cables





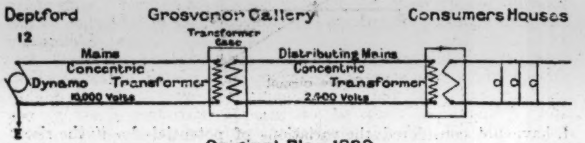


effect of capacity is to lower the potential, and when its magnitude is sufficient it reduces the potential of the conductor to that of the earth, for it does not allow time enough for the charge to accumulate. Hence, a concentric main, whether its outer conductor is connected to earth or not, has its potential reduced practically to that of the earth. The use of the earth is imperative to dissipate the static charge and to secure safety. A permanent and efficient earth makes the cable safe to person, and dangerous to apparatus only, which can be fully protected by fuses. Unless, however, it is most effectively applied, it may become a source of danger to person also, and of disturbance to telephones, for the existence of a variable fault might produce a shifting of potentials which would destroy the security.

It is very easy by the aid of such diagrams to study the distribution at any phase of the potential, or at any instant of flow. The capacity acts as a kind of break or damper on the currents, and its tendency is to vary the rate of rise of potential, and to flatten the curve of rise and fall of the currents. With direct and intermittent currents it acts as a fly-wheel, but with alternate currents it acts more as a spring, or as an air cushion in a hose-pipe. Its effect with ordinary frequencies is not material; but the rapid alternations of stress, and displacement in the dielectric must have a tendency to heat that material. It will be readily seen how the earth dissipates the charge at once, but it also shows that when a disconnection takes place, this discharge may be very unpleasant.

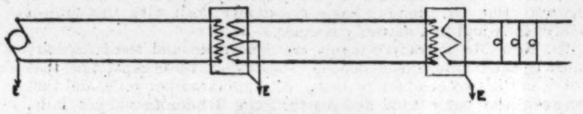
21. Such being the distribution of potential on a concentric main, and also on a system of two parallel conductors, it is now desirable to compare their relative security. We have to consider, not alone what happens when everything is in order, but what happens when accidents and faults arise. Nothing is perfect—we have only before us a choice of evils. Earth is the electrician's bane, but there may be circumstances under which it may become his antidote. No one but Mr. Ferranti has had the temerity to employ the earth as his antidote, and I must confess that I have been compelled to effect a compromise with him on the subject. His original form of cable was designed so as to place the outer tube completely to earth, but my own experiments * and his experience have shown that this outer tube must be thoroughly well insulated to prevent the introduction of serious disturbing effects on telegraphs and telephones. In Rome, where Siemens concentric cables are largely used, but without earth, the outer insulator was so frequently pierced, that Prof. Mengarini found it necessary to make the outer insulation thicker and better than the inner. The sudden stoppage of a flow of great energy from any cause must lead to effects analogous to those of momentum, and unless some buffer or cushion is provided, either in the form of a condenser or of the earth, a heaping up of pressure must occur somewhere, and sparking and rupture follow.

12



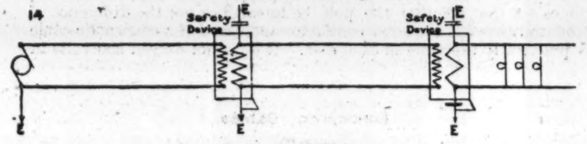
Original Plan 1880.

13



In use November 1890.

14



Authorised 1891.

22. Mr. Ferranti claims for his concentric mains with the outer conductor earthed at one end, as shown by fig. 11:—

1. Absolute safety in handling by workmen, and freedom from fire risk.
2. Dispersal of the static change accumulated on the conductors.
3. Freedom from disturbance on neighbouring wires.

I can corroborate the last point. We in the Post Office are now quite unaware whether the Deptford mains are at work or not. It was not always so. At first, starting with imperfect cables, the disturbances were very serious.

The compromise effected between the Postmaster-General, the Board of Trade, and the London Electric Supply Corporation is shown by figs. 12, 13, and 14, which also give some of the changes that have been made.

We allow earth on the outer conductor at Deptford and at each distributing station, but not on mains other than concentric, or on the house service excepting through a safety device.

With regard to high-pressure alternating-current systems generally, earth cannot be admitted on house wires, because, with its use, high insulation is imperative to reduce fire risks, and high insulation cannot always be maintained. Leakage means danger, in spite of fuses and safety devices. Fire and life risks are intensified by bad earths. Good earths are very difficult to secure, and alternate currents do not like earth; that is the resistance of earth to alternate currents is much greater than that to direct currents.

We can secure safety in houses by—

1. Good materials.
2. Good workmanship.
3. High insulation.
4. Well-designed safety devices.
5. Frequent tests.
6. Incessant personal supervision.
7. No EARTH.

In the wiring of houses, supply companies and corporations cease to exercise responsibility. They deal with confiding customers, irresponsible contractors, untechnical and uneducated *employés*, and all sorts and conditions of men. Were it not for the Board of Trade to regulate our mains, and the fire insurance companies to regulate our house wires, electric lighting in England would be as dangerous a pursuit as it appears to be in the United States.

23. The Board of Trade has forbidden the use of earth on separate conductors. This is absolutely necessary, for, except with concentric mains, the use of earth on one conductor might be exceedingly dangerous if the other conductor, by fault or otherwise, made earth. The inner conductor of a concentric main is so hermetically sealed, and so thoroughly protected by a succession of coatings, that it is well nigh impossible for a leak to earth to be caused on it. Faults would take the form of a short circuit, not of earth. A system to earth is one which has been placed at full cock; a permanent fault has been put on intentionally. Equilibrium has been disturbed, and it is the security of the inner conductor of the concentric main that alone makes it acceptable.

24. The chief accident that one has to fear in the high-pressure alternate current system is the piercing of the insulating medium between the primary and the secondary conductors of the transformer, and the formation of a contact between the two. Such a fault admits the high-pressure into the low-pressure system, and has been the source of nearly all the troubles that have arisen. Earthing the conductor puts a great strain on this medium. Risks of fire are increased. Additional preventive measures are necessary, and hence safety devices—the best at present in the market being Major Cardew's.

The use of safety devices which earth the conductor *at once* when the transformer is pierced, or when high pressure enters the low-pressure system, is, in my opinion, an absolutely necessary safeguard, and I never issue any specification without requiring Cardew's device, which is thoroughly effective and reliable.

25. The use of low or of high pressure should not be a question of opinion or of objection. The supposed waste, danger, and difficulties of the one are disappearing under the able tuition of experience; while the complicated regulation and variable distribution of the other are submitting to inventive skill. It is now a question of calculation and of finance. The only variable is the number of feeding points. The determining cause and the uncertain element is the density of lamps per acre, or per mile of street. We start with this initial difficulty—that we do not know our customers, and we have to prepare for a visionary *clientèle*.

This paper has been a little discursive. Its principal object is to direct attention to the simplicity of the two-wire parallel system of distribution, to the security of the concentric main, to the devices to promote the safety of the high-pressure system, and, above all, to the necessity for regarding the whole question from the engineering maintenance point of view rather than from that of the speculative promoter.

Discussion.

(*Authorised Abstract.*)

Mr. Swinburne remarked that in 1889 he had discussed the subject of Disturbance in Telephones with reference to concentric cables earthed at one end. Many persons thought no trouble would arise from such a course. This, he believed, was a mistake, for the outside conductor being near earth had a considerable capacity relative thereto. If a large current, say of 250 amperes, was passing, the pressure between the two ends of the outer conductor would be about 210 volts, and this would cause a considerable earth current to surge backward and forward between London and Deptford. The effect of these currents had, he believed, not yet been observed, but it would become noticeable when the load got heavy. Mr. Preece, he said, thought earthing the secondary of a transformer tended to lead the current into temptation, but as a matter of fact the temptation was diminished by earthing the middle of the secondary. If this be done neither secondary main could differ by more than 50 volts from the earth potential, whereas if one end be earthed or neither, the risk and danger were considerably increased.

The further discussion was adjourned.

On the Most Economical Mode of Feeding a Low-Pressure Network.

By R. E. Crompton, Vice-President.

(*To be discussed on May 21st, 1891.*)

The advocates of alternating transformer (hereafter called the A.T.) system of distribution, appear at last to be in agreement with those who designed low-pressure systems, in that they admit that for the supply of towns of ordinary compactness a low-pressure network must be provided. Their practice in the future is to diverge from their practice in the past, in that they fix the transformers only at the feeding points of the network, instead of in each of the consumers' houses. In other words, they propose to use high-pressure feeders, consisting of cables carrying a high-pressure primary current, transformed so as to supply a low-pressure network on either the two or three-wire system, by a transformer fixed at the feeding point. Mr. Ferranti, Mr. Gordon, and other gentlemen advocate banking the transformers at these feeding points, and the use of automatic apparatus to switch their transformers in as the load requires. Others, such as Mr. Mordey, prefer to spend more money on the perfecting of a design of a single transformer at the feeding point, so as to avoid the complication of automatic apparatus. As it was evident that there is a certain length of feeder at which the low pressure direct system fails to compete successfully in first cost and that of upkeep with the above-described high-pressure A.T. feeder, I have recently investigated the question in order to find out at what mean length of feeders the low-pressure and high pressure systems compete on equal terms of first cost, cost of upkeep, and efficiency. The result of my investigation is to show that when a three-wire low-pressure system, distributing direct to 110-volt lamps, is compared with an A.T. system, distributed by 2,000-volt feeders, transformed to supply the same three-wire network, the average annual efficiency of the feeders in both cases being 90 cent., the low-pressure feeder is cheaper for all distances up to 2,400 yards, each of the feeders being calculated to supply 100 kilowatts; and the annual cost for upkeep, including a sum of 5 per cent. for interest on the capital, will be about £290 per annum. These large figures lead me to compare with them the known cost of upkeep of feeders carrying the same load which are now in use in London. I find that feeders of an average length of 600 yards cost about £300 each, and for interest and upkeep, £25 per annum. This comparison shows that if we increase the length of each feeder by 1,800 yards, or say one mile, it increases the supply company's annual upkeep charges by not less than £260 per annum per feeder. If we apply these figures to a company supplying a district of about a square mile, which, if it had within it two generating stations, could feed its network with 10 short feeders, and substitute for these two central stations one external generating station one mile distant from the outside of the district, the extra cost of upkeep of the 10 long feeders will be £2,600 per annum. At a load factor of 10 such a district would sell 876,000 units per annum; therefore the above sum of £2,600, divided by this number of units, is equal to 0·72 of a penny per unit sold. Now even at present the cost per unit for coal and ground rent (which are the only two items affected by the removal of the site from a central position to a distant point) only slightly exceeds 1d. a unit, and in all probability during the present year this figure will be brought down to a sum approximately the same as the above-mentioned upkeep of the feeders, viz., 0·72, which I have shown is the actual cost of upkeep of the feeders only. This shows the absurdity of imagining that any saving can be effected by this mode of feeding a network, and it is quite evident that those who have advocated the system have never seriously looked at the matter from this point of view. In such cases where really great savings can be effected by generating the energy at a distance from the district to be supplied, as in the case of water power, Mr. Ferranti's original Deptford scheme of supplying one or two large transformer stations by currents of very high E.M.F. is in all probability the right one; but the distribution must be modified from Mr. Ferranti's original intention; that is to say, he need not transform twice, but merely supply several transformer stations by his high pressure mains, and feed the surrounding districts by not only a low pressure network, but also low pressure feeders. I have not at command the figures as to the cost of mains of extreme high pressure such as Mr. Ferranti advocates; but I have no doubt that he will be able to show, even for such distances as one or two miles, a very considerable saving on the separate feeder system that I have just criticised.

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* "On the Disturbances arising from the Use of Earth for Electric Lighting Purposes," March 28th, 1889.

TABLE I.—COMPARISON OF COST OF 100-KILOWATT FEEDERS.

	A. 220-volt low-pressure feeder. Mean annual efficiency, 90 per cent. 450 yds. bare copper; 150 yds. cable in pipes; total, 600 yds.	B. 220-volt low-pressure feeder. Mean annual efficiency, 90 per cent. 1,800 yds. bare copper; 600 yds. cable in pipes; total, 2,400 yds.	C. 2,000-volt A.T. feeder, with transformer in pit. Mean annual efficiency, 90 per cent. 2,400 yards concentric cable, laid in part of low-pressure culvert or in open.
	£	£	£
Excavation, or extra width culvert and pipes, at 5s. per yard...	150	600	600
Transformer pit	...	...	60
Bare copper, at £90 per ton, laid...	78	1,260	...
Low-pressure cable (250 volts), rubber insulation, laid	65	1,020	...
High-pressure cable (concentric), 2,000 volts, laid	...	...	1,300
Transformer and apparatus, including fixing...	...	...	440
Total	£293	£2,880	£2,400

TABLE II.—COST OF UPKEEP OF 100-KILOWATT FEEDERS.

	A.			B.			C.		
	£	s.	d.	£	s.	d.	£	s.	d.
Culvert and pipes, &c., at 1 per cent.	1	10	0	6	0	0	6	0	0
Transformer pit, at 2½ per cent.		...			...		1	10	0
Bare copper, at 1 per cent.	0	15	8	12	12	0		...	
Low-pressure cable, at 8 per cent....	5	4	6	81	10	0		...	
High-pressure cable, at 8 per cent....		...			...		104	0	0
Transformer and apparatus at 10 per cent.		...			...		44	0	0
Small apparatus	2	10	0	10	0	0	10	0	0
Interest on total, at 5 per cent.	14	13	0	144	0	0	120	0	0
Total	£24	13	2	£254	2	0	£285	10	0

Table I. shows you the details of first cost of the 600 yards low pressure, 2,400 yards low pressure, and 2,400 yards A.T. feeder with transformer.

Table II. shows the details of cost of upkeep of the same three feeders. It will be noticed I have taken the cost of upkeep on excavation or concrete work below ground at 1 per cent. per annum, on the transformer pit at 2½ per cent. per annum, on the bare copper at 1 per cent., on both low and high-pressure cables at 8 per cent.; although I might well claim that the cost of upkeep of the high-pressure cable would be a higher percentage on its first cost than the low. The transforming and switching apparatus I have taken at 10 per cent., and I have added a small charge for the upkeep of surface and inspection boxes. This is taken without reference to pressure, in proportion to the length laid. The cost of the low-pressure feeders has been carefully taken out in accordance with our London practice, and that of the high-pressure feeder has been taken out from estimates received from cable and transformer makers. I believe that these figures may be said to be sufficiently correct to make the comparison a fair one; at any rate, I think no one will venture to say that either the first cost or upkeep is taken at too high a figure. For the purposes of my argument they are sufficient to show that 100-kilowatt feeders of 2,400 yards long cannot be put down at less than £1 a yard, and cannot, including transformers, be maintained at less than 2s. 4d. a yard per annum.

Visit of the Physical Society of London to Cambridge.

ON Saturday, the 9th inst, the Society varied its ordinary procedure by paying a visit to the ancient seat of learning situated on the banks of the Cam. Assembling at Liverpool Street Station members and visitors to the number of about one hundred were conveyed in saloon carriages by the 11 o'clock express direct to their destination, the whole journey being accomplished in about seventy-five minutes. Amongst those present were Dr. E. Atkinson, Prof. Ayrton and Mrs. Ayrton, Mr. Walter Baily, Mr. Shelford Bidwell and Mrs. Bidwell, Mr. D. J. Blaikley, Mr. T. H. Blakesley and Mrs. Blakesley, Mr. J. T. Bottomley, Mr. C. V. Boys, Prof. Carey Foster, Mr. Conrad W. Cooke, Prof. Fitzgerald, Dr. E. Frankland and Mrs. Frankland, Dr. W. R. Hodgkinson, Prof. O. J. Lodge, Prof. Meldola, Prof. Perry and Mrs. Perry, Prof. Rücker, Dr. Sumpner, Prof. S. P. Thompson and Mrs. Thompson, Mr. A. P. Trotter and Mrs. Trotter, and Mr. G. M. Whipple.

On arriving at the historic town the party became the guests of the Cambridge members and proceeded to Emmanuel College, where they were received by Mr. W. N. Shaw, M.A. Various groups visited the cloisters, chapel and gardens, and at 1 o'clock lunch was provided in the College Hall. At 2·30 a meeting of the Society was held in the lecture room of the Cavendish Laboratory. The papers read were all by authors resident in Cambridge, and the abstracts given below will sufficiently indicate the variety of the subjects brought before the Society. After the meeting the visitors inspected the Cavendish Laboratory. Amongst the many interesting instruments and apparatus to be seen, specially noticeable were Prof. J. J. Thomson's 50-feet vacuum tube, glowing from end to end with a luminous discharge; Mr. Shaw's pneumatic bridge, by which the pneumatic resistance or conductivity of various shaped orifices and channels can be compared; and the new air condensers to be used by Mr. Glazebrook as standards. The Cambridge Scientific Instrument Company had an interesting exhibit, including a dividing engine, Boys's radiomicrometer, electrically driven tuning-forks, and various recording instruments, amongst which was Galton's apparatus for registering the growth of plants. Other things which attracted attention were Glazebrook's spectrophotometer; Lord Rayleigh's coils and apparatus used in his determination of the ohm; a collection of models, medals, and instruments formerly belonging to Prof. Maxwell; the resistance standards of the British Association, together with the historic rotating coils and electro-dynamometer used in the determination of the B.A. unit.

Tea was served in the combination room of Trinity College, and a majority of the visitors returned to town by the 8 o'clock express, greatly pleased with the day's outing; others, however, prolonged their visit until Monday, and had opportunities of discussing important physical problems with the Cambridge members.

The meeting was in every sense a great success, and will long be remembered as a red-letter day in the history of the Society.

At the Science meeting held in the Cavendish Laboratory, Prof.

Ayrton, F.R.S., President, in the chair, the following communications were made:

"Some Experiments on the Electric Discharge in Vacuum Tubes."

By Prof. J. J. Thomson, M.A., F.R.S.

The phenomena of vacuum discharges were, he said, greatly simplified when their path was wholly gaseous, the complication of the dark space surrounding the negative electrode and the stratifications so commonly observed in ordinary vacuum tubes being absent. To produce discharges in tubes devoid of electrodes was, however, not easy to accomplish, for the only available means of producing an electromotive force in the discharge circuit was by electro-magnetic induction. Ordinary methods of producing variable induction were valueless, and recourse was had to the oscillatory discharge of a Leyden jar, which combines the two essentials of a current whose maximum value is enormous and whose rapidity of alternation is immensely great. The discharge circuits, which may take the shape of bulbs or of tubes bent in the form of coils, were placed in close proximity to glass tubes filled with mercury, which formed the path of the oscillatory discharge. The parts thus corresponded to the windings of an induction coil, the vacuum tubes being the secondary and the tubes filled with mercury the primary. In such an apparatus the Leyden jar need not be large, and neither primary or secondary need have many turns, for this would increase the self-induction of the former and lengthen the discharge path in the latter. Increasing the self-induction of the primary reduces the E.M.F. induced in the secondary, whilst lengthening the secondary does not increase the E.M.F. per unit length. Two or three turns in each were found to be quite sufficient, and on discharging the Leyden jar between two highly polished knobs in the primary circuit, a plain uniform band of light was seen to pass round the secondary. An exhausted bulb containing traces of oxygen was placed within a primary spiral of three turns, and on passing the jar discharge a circle of light was seen within the bulb in close proximity to the primary circuit, accompanied by a purplish glow which lasted for a second or more. On heating the bulb, the duration of the glow was greatly diminished, and it could be instantly extinguished by the presence of an electro-magnet. Another exhausted bulb surrounded by a primary spiral was contained in a bell jar, and when the pressure of air in the jar was about that of the atmosphere, the secondary discharge occurred in the bulb as is ordinarily the case. On exhausting the jar, however, the luminous discharge grew fainter and a point was reached at which no secondary discharge was visible. Further exhaustion of the jar caused the secondary discharge to appear outside the bulb. The fact of obtaining no luminous discharge either in the bulb or jar, the author could only explain on two suppositions, viz., that under the conditions then existing the specific inductive capacity of the gas was very great, or that a discharge could pass without being luminous. The author had also observed that the conductivity of a vacuum tube without electrodes increased as the pressure diminished until a certain point was reached, and afterwards diminished again, thus showing that the high resistance of a nearly perfect vacuum is in no way due to the presence of the electrodes.

One peculiarity of the discharges was their local nature, the rings of light being much more sharply defined than was to be expected. They were also found to be most easily produced when the chain of molecules in the discharge were all of the same kind. For example, a discharge could be easily sent through a tube many feet long, but the introduction of a small pellet of mercury in the tube stopped the discharge, although the conductivity of the mercury was much greater than that of the vacuum. In some cases he had noticed that a very fine wire placed within a tube on the side remote from the primary circuit would prevent a luminous discharge in that tube.

"Some Experiments on the Velocities of the Ions."

By Mr. W. C. D. Whetham, B.A.

In studying electrolysis the question as to whether there is any transference of solvent when a porous wall is absent presented itself to the author. The ordinary methods of testing for transference, such as by increase of pressure or by overflow, not being available when there is no diaphragm, the author used different coloured solutions of the same salt, such as cobalt chloride in water and in alcohol, the former of which is red and the latter blue. By putting the solutions into a kind of U-shaped tube, any change in the position of the line of junction of the two liquids could be measured. Two aqueous solutions in which the anion was the same were also tried, one combination being cupric chloride and common salt, and in this case the line of demarcation traversed about 7 inches in three hours. The results hitherto obtained by this method agreed fairly with those found by Kohlrausch.

"On the Resistance of some Mercury Standards."

By Mr. R. T. Glazebrook, M.A., F.R.S.

In 1885 M. Benoit, of Paris, supplied the author with three mercury standards nominally representing the Paris Congress ohm, now commonly known as the legal ohm. Tests of these standards were described in a paper read before the Physical Society in 1885 by the present author. Recently he had occasion to compare two of the standards with the British Association coils. The mean of many concordant results gave the resistance of one of the mercury standards (No. 37) as 1·01106 B.A.U., whilst that of the other (No. 39) was 1·01033 B.A.U. Expressing them in legal ohms the present resistances are (No. 37) ·99986 and (No. 39) ·99913, whilst in 1885 the values obtained were (No. 37) ·99990 and (No. 39) ·99917. This shows that within the limits of experimental error the ratios of the mercury standards to the B.A. coils have remained practically unchanged during 6 years. The numbers given above are based on Lord Rayleigh's determination of the specific resistance of mercury which differs appreciably from that found by Mascart and other observers. Taking the mean of the later concordant determinations the value of the mercury standards expressed in legal ohms become (No. 37) 1·00033 and (No. 39) ·99950. The values given by the maker were 1·00045 and ·99954 respectively, showing a very close agreement. The author also found that refilling No. 37 from the same sample of mercury produced no appreciable change in its resistance whilst No. 39 was somewhat affected by a similar operation.

Experiments on the coefficient of increase of resistance of mercury with temperature gave the value ·000872 as the mean coefficient between 0° and 10° C, a number rather less than that obtained by Kohlrausch.

In the discussion on Prof. Thomson's paper,

Prof. Fitzgerald said the beautiful experiments were likely to lead to very important results. He did not quite understand how placing a fine wire in a vacuum tube could prevent the luminous discharge, for if the wire was on the side remote from the primary, and if there was any great increase in specific inductive capacity he would have expected the air to screen the wire.

Prof. Lodge asked for further information as to the action of the magnet in preventing the after glow, and in some cases precipitating a luminous discharge. The experiment with the exhausted bulb within the bell jar was also difficult to understand, and he did not see why one of Prof. Thomson's two suppositions must necessarily be true.

The President enquired whether Prof. Thomson had tried Mr. Crookes's experiment in which the electric pressure necessary to produce a discharge was greatly lessened by putting a phosphorescent material in the tube.

Prof. Thomson, in reply, said he had not tried the experiment, but the phosphoresence he had observed was of quite a different character to that produced in Mr. Crookes's tubes. To Prof. Fitzgerald he said the action of the wire was probably a question of time, and thought the whole field was in some way thrown on the wire and thus discharged. In reply to Prof. Lodge, he had not ascertained the true nature of the effect of a magnet on the glow, but he believed the glow to be due to a combination which might be prevented or facilitated by the action of the magnet causing the density to be different in different parts of the bulb.

On the motion of Prof. Ayrton, seconded by Prof. Rucker, a hearty vote of thanks was accorded to the authors for their valuable and interesting communications, and for the kind manner in which the society had been received and entertained by the Cambridge members. Prof. Thomson and Mr. Glazebrook acknowledged the vote.

THE DELIVERY OF TELEGRAMS.

Mr. Howard Vincent, C.B., M.P., lately called the attention of the Postmaster-General to the facilities afforded in some of the Australasian colonies for the delivery of telegraphic messages by post, thus saving the porterage to the Department and expense to the receivers of telegrams, without, in many cases, any serious loss of time being incurred, and suggested that as the same facilities existed in England, a space should be set apart upon the telegraph form to remind the sender of the opportunity of causing the telegram to be delivered by post. Mr. J. C. Lamb, controller of the Telegraph Department, who has taken great interest in the subject, has written in reply that the Postmaster-General had called for reports upon the subject from some of the practical officers of the department, and that these reports fully supported the view of the hon. member. "It is clear, however," Mr. Lamb adds, "that the sender must possess a thorough acquaintance with the local arrangements for the delivery of letters. Without this intimate local knowledge he would often find that a message ordered to be delivered by post would not reach its destination until the following morning, in which case it would be of no more use than a letter posted in time to catch the evening mail. In a very large number of cases there is only one delivery during the day, and that delivery begins at an early hour in the morning—before the local telegraph office is open for business. In other cases the second delivery begins at so early an hour that if a telegram were sent in the afternoon it would be too late to catch it, while in some cases there is this further complication that two mails for the same place are delivered from different offices, and that the delivery of telegrams is effected from a third office. . . . . In view of all the facts, the Postmaster-General can come to no other conclusion than that it would not be to the public interest to invite the senders of telegrams to rural districts generally to order their telegrams to be delivered by post, as the result would often be to create disappointment and dissatisfaction." Mr. Howard Vincent, in writing to thank Mr. Lamb, says :—"You will, I am sure, forgive me for adhering to the view that eight senders of telegrams out of ten are sufficiently acquainted with the postal and telegraphic facilities open to the addressee to know whether a telegram delivered by post will reach him in sufficient time."

NOTES.

The Woodfield Syndicate, Limited.—This syndicate has been formed with the intention of carrying out some experiments on a large scale in connection with electricity, under the supervision of Messrs. W. T. Goolden & Co., without interfering with their ordinary manufacturing business.

The National Telephone Electrical Society, Midland Branch.—The second annual *conversazione* of the society was held at the Colonnade Hotel, New Street, on Friday, May 15th. Among those present were: Mr. Alfred Coleman, M.I.E.E., President (general manager of the company); Mr. A. E. Cotterell, Vice-President (district manager); Prof. J. H. Poynting (local director); Mr. J. Newburn (manager, Hanley); Messrs. Ollennshaw, Derby; Lowe, Coventry; Johnstone, Kidderminster; Currell and Swettenhaw, Hanley; Loftus, Baxter, Ghent, Barber, Fenton, Turner, Wicker, Firth, Edwards, Lloyd, Morley, Alfred Peacock (honorary secretary), &c. After tea the annual report was read by the secretary, which showed that papers had been given embracing nearly every phase of electrical work. The president (Mr. Coleman) then welcomed the visitors present, to which Prof. Poynting responded. The society's indebtedness to its president and vice-president was then expressed, to which they respectively answered.

The Electric Light at Bath.—At a meeting of the Town Council last week, the report from the Electric Light Committee upon Prof. Forbes's statement (which appeared in our last issue) was considered. The mover of the adoption of the report commented upon the circumstance that Mr. Massingham had fairly carried out the terms of the contract, not that Prof. Forbes thought they drew up the very best possible contract they could have had. Mr. Massingham had fought his way bravely, and when Prof. Forbes's recommendations were carried out it would be a very good installation. The committee recommended that a superintendent of the electric light should be appointed, who would see that the installation was kept in good order. In opposition to the adoption of the report it was urged that the city was not getting what was paid for, that the council had acted too impulsively in the matter, and that it would be unwise to vote for more lamps until they were assured they got all they were entitled to under the contract. On the other hand, an opinion was expressed that the ratepayers were satisfied with the electric light. The clerk, at the request of a member, quoted from the contract, showing that Mr. Massingham undertook to supply 81 public electric arc lamps of 1,200 candle-power each lamp, and to "supply the said lamps, and keep each lamp of the said 81 lamps lighted during such hours as shall be from time to time prescribed by the local authority, not exceeding an average of ten hours per night during the term of the contract, by means of the Thomson-Houston system of lighting, or some other system to be approved by the local authority." It was contended, in reply to the complaints that were made, that the streets were very well lighted, and that if the installation admitted of improvement, as an experiment it had been successful. An amendment referring the report back to the committee was lost, 11 voting for it and 12 against. The motion for the adoption of the report was negatived by 13 to 12, but it was pointed out that an alderman who had voted with the majority was interested in the gas company, and the Mayor said his vote was certainly nullified. Eventually, on the suggestion of the mayor, the chairman of the Electric Light Committee consented to the report being taken back for further consideration.

Frankfort Electro-Technic Exhibition.—The *Standard* correspondent says :—"The Electro-Technic Exhibition was opened at Frankfort-on-the-Main on Friday, in presence of the Empress Frederick, Princess Margaret of Prussia, the Grand Duke, Princess Alix and the Landgravine of Hesse, Count Eulenburg, President of the Prussian Province of Hesse-Nassau, and the chief local dignitaries. Herr Sonnemann, Chairman of the Committee, after welcoming the visitors, pointed out the utility of an exhibition of that kind, and said that foreigners, as well as Germans, had recognised this by their extensive participation in it. With regard to the extent of the present exhibition, he stated that the first German show of the kind, to wit, the Exhibition at Munich in 1882, had only 160 horse-power at its disposal. The Vienna one in 1883 had 1,200 horse-power, while this at Frankfort, which is the first International Electric Exhibition, is employing no less than 4,684 horse-power. He concluded by thanking the German Emperor, the Empress Frederick, the Grand Duke of Hesse, and the various German Governments, for the support they had given to the enterprise. Finance Minister Dr. Miquel, as honorary President, in declaring the exhibition open, took the opportunity of thanking the Empress and the Grand Duke for the interest they had shown in the enterprise. After three cheers had been proposed by the Burgomaster of Frankfort to the Emperor, the Empress Frederick and the Grand Duke walked through the exhibition. Among other things, they heard the very successful telephonic transmission of an opera by Delibes, which was being performed in the Opera House at Munich, and then listened to an English song given by an Edison phonograph. The Empress and the other distinguished visitors expressed great satisfaction with what they had seen. In the afternoon there was a banquet, and in the evening festive performances in the Exhibition Theatre and in the Opera House."

"Honour to Whom Honour is Due."—This is the appropriate heading of a letter which Sir Frederick Perkins has published in the London Press in commendation of the scientific labours of Mr. W. H. Preece, F.R.S., the chief electrician to the Post Office. "Mr. Preece, in the old days of the International Company, was in charge of the telegraph district of which Southampton was the centre. He formed a domestic tie of the closest character, and left behind him many friends, who are still living there, and who remember his companionship as that of a clever scientist and cultured gentleman." Sir Frederick Perkins specially refers to the successful extension of telephone communication between London and Paris, and urges that: "As a nation we should certainly not be slow to honour the men by whom this wonderful result has been brought about. The telegraphic service of this country, and, indeed, of the whole world, is indebted to a greater extent than can possibly be known to the scientific ingenuity, the inventive powers, and the patient investigations of Mr. Preece, who has been largely instrumental in bringing to a successful completion the telephonic service between the two capitals, now daily proving its growing utility, and promising yet further and more wonderful developments. The British people are justly proud of those whose services reflect honour upon the nation, and whose achievements render the resources of civilisation increasingly valuable to our age and race. No man is more worthy of some mark of public distinction in this respect than Mr. Preece, whose life has been so largely devoted to the perfection of telegraphic science, and who has spent many years in the service of the country, with what advantage to us and to the world the progress made in the manifold applications of electricity and its latest triumph in the opening of the London and Paris telephone amply attest. A more popular or appropriate act could hardly be performed by the head of the Government than that of advising Her Majesty the Queen to confer some mark of distinction upon Mr. Preece for the splendid work he has done in the highest department of practical science—a recognition which you, I am sure, sir, would be the first to approve; and one which the whole country, and the scientific world especially, would heartily rejoice to see conferred."

Telephones in Italy.—The Italian Government proposes to acquire the telephone systems in that country.

Electric Lighting at Morecambe.—At a meeting of the Morecambe Local Board last week, Mr. William Aspden presiding, an application on behalf of Messrs. Andrews and Preece, electricians, Bradford, for the assent of the board to an intended application to the Board of Trade for an extension of time for the commencement of the works necessary for the supply of electricity to Morecambe, under the provisional order obtained by that firm, was acceded to for a further period of twelve months.

Telegraph Manufacturing Company.—The business of this company having outgrown the accommodation at the Helsby Works, premises at Liverpool have been taken and fitted up for the manufacture on a large scale of all kinds of electrical instruments. For several reasons it was determined to work all the machinery by electro-motors, the current for which is supplied by the Liverpool Electric Supply Company. A 10 H.P. motor, taking about 60 units per day of 10 hours, drives some large lathes and the heavier machines for drilling, screwing, planing, &c., while on another floor two motors, each of 3 H.P. and taking 30 units per day of 10 hours, drive about 30 lathes as well as two saws, two drills, a grindstone, and other tools. After an experience of two months the company is satisfied that by dispensing with a steam or gas engine the advantages more than compensate for any apparent extra costliness.

Lighting Tenders Wanted.—LONDON, N.W., June 1st.—For supplying and erecting arc lights, columns for same, and road shelters, either together or separate, for the Vestry of St. Pancras. Copies of specifications, schedules, and designs can be obtained at the office of Prof. Henry Robinson, C.E., engineer to the vestry, 13, Victoria Street, S.W., on payment of 10s., which will not be returned, on or after the 23rd inst. Tenders to be sent in by June 1st to Mr. T. E. Gibb, vestry clerk, Vestry Hall, Pancras Road, N.W.

ROMFORD, June 1st.—For lighting the public lamps by electricity, gas, or other illuminant, as to about 123 of such lamps from sunset to sunrise during period beginning August 10th and ending June 10th, 1892 (except seven nights in each month when the lights may be extinguished at 11 p.m.), and as to about 10 of such lamps during 12 calendar months from September 1st, for the Romford Local Board. Tenders, to include the cost of lighting, cleaning, and repairing, to be sent to Mr. A. H. Hunt, clerk, Romford, on June 1st. Further particulars may be obtained on application to the surveyor.

The French West India Cables.—The following figures relating to the subsidies and estimated traffic receipts of the Compagnie Française des Télégraphes Sousmarins are extracted from a French contemporary :—

		Francs.
Martinique.	During 25 years' annual subsidy ...	50,000
Guadeloupe	,, ,, ,, ...	60,000
Cayenne	,, ,, ,, ...	100,000
Paramaribo	,, 20 ,, ,, ...	50,000
Curaçao	,, 25 years' annual guarantee	95,000
	Total subsidies and guarantees ...	355,000
Estimated traffic (yearly)—		
Venezuela		200,000
Republic of San Domingo		150,000
Republic of Hayti		150,000
Curaçao		100,000
Martinique		50,000
Guadaloupe		50,000
French Guiana (Cayenne)		50,000
Dutch Guiana (Paramaribo)		50,000
Brazil (Vizeu)		1,250,000
	Total estimated traffic...	2,050,000
	Total subsidies and guarantees ...	355,000
	Total estimated revenue	2,405,000

The expenditure is estimated at 485,000 francs per annum, of which 350,000 francs are put down to the working of 13 stations, and 135,000 francs to general expenses.

Tramway in Belgrade.—A concession for 45 years has been granted for the erection and working of a tramway in this city. Horse-power will be found in the town, and either steam or electric power outside the town to Topschider.

Lightning Rods.—A vivid flash of lightning, immediately followed by a tremendous peal of thunder, heralded a storm at Alnwick on Wednesday. The lightning struck the chimney of the armoury magazine and stores of the 3rd Northumberland Fusiliers, demolishing it, and cracking the wall almost to the ground, notwithstanding that on the opposite chimney stack on the same roof a lightning conductor is affixed. A sergeant narrowly escaped being injured by the falling *débris*. The incident will probably be seized upon in some quarters for the purpose of showing that lightning rods as now applied are useless ; but it will doubtless be discovered that this particular rod had no proper earth connection.

Lighting of Mumbles.—At one of the meetings of the Mumbles Local Board a member introduced a motion with reference to the lighting of the district with electricity in lieu of gas, which has to be conveyed from a neighbouring town several miles away. The Mumbles, which is popularly known as "The Brighton of Wales," is a rapidly rising seaside resort on the Glamorganshire coast, and much frequented during the summer months by visitors from all parts. The present system of public lighting is far from satisfactory, and there is a wide-spread feeling in local circles that electricity would come as "a boon and a blessing." For one thing, it would be decidedly cheaper than gas, and there can be no doubt that if the electric light was once inaugurated in the Mumbles, it would prove a success in every respect. Householders grumble at the high price they are obliged to pay for their gas, whilst one local board considers the lighting contract excessive ; but then it has no option in the matter. The motion brought forward that the place be lighted with electricity was most favourably received ; but up to the present, nothing definite has been decided upon.

Gazette Notices.—At extraordinary general meetings of the Woodhouse and Rawson Electric Supply Company of Great Britain, Limited, held at 11, Queen Victoria Street, E.C., the 20th day of March, 1891, and the 17th day of April, 1891, the subjoined resolution was duly passed and confirmed :—"That the Woodhouse and Rawson Electric Supply Company of Great Britain, Limited, be, and is hereby, wound up voluntarily, in pursuance of the provisions of the Companies Act, 1862." Messrs. Albert Hoster, Thomas Harrison Lambert, and Frederick Lawrence Rawson were appointed liquidators.

The Simplex Electrical Syndicate, Limited, on the 22nd day of April, 1891, duly passed a special resolution at a meeting held at 4, Hercules Passage, Threadneedle Street, London, as follows :—"That the Simplex Electrical Syndicate, Limited, be and is hereby wound up voluntarily, in pursuance of the provisions of the Companies Act, 1862." Which said special resolution was duly confirmed on the 7th day of May, 1891.—C. L. W. FITZGERALD, Chairman.

The creditors of the Maxim-Weston Electric Company, Limited, are required, on or before the 31st day of May, 1891, to send their names and addresses, and the particulars, in writing, of their debts or claims, to John Marks, of 113, Great Russell Street, Bloomsbury, Middlesex, or to Louis Swaby, of 23, Churchfield Road, Ealing, Middlesex, the liquidators of the said company ; and notice is hereby given, that at the expiration of that time the said liquidators will proceed to distribute the assets of the company among the parties entitled thereto, having regard only to the claims and demands of which they shall then have had notice ; and that the liquidators will not be liable for the assets, or any part thereof, so distributed, to any person or persons of whose claim or demand they shall not then have had notice.

The Electric Company give notice that a meeting will be held at 3, Bucklersbury, on the 18th of June, for the purpose of presenting an account, showing the manner in which the winding up has been conducted. A similar meeting of the Automatic Electric Railway Signal Company, Limited, will be held at the Small Sale Room, Exchange Station Buildings, Liverpool, on the 22nd of June.

Notice is also given that the creditors of the Electrical Engineering Corporation, Limited, are required, on or before the 6th day of June next, to send their names and addresses, and the particulars of their debts and claims, and the names and addresses of their solicitors (if any), to Francis William Pixley, the liquidator, at 24, Moorgate Street, London, E.C.

The City and South London Railway.—The company has thought it advisable to introduce a penny train service between the hours of 6.45 a.m. and 8.0 a.m. for any distance and from any station.

Trade.—The directors of the General Electric Company, Limited, of London and Manchester, have given great satisfaction to the *employés* of their several departments by following the example of the Amalgamated Engineers, in reducing the number of working hours to 53 per week.

Heckmondwike Electric Lighting.—On Thursday the provisional order of the Board of Trade, under the Electric Lighting Acts of 1882 and 1888, which gives the Local Board of Health power to light the town by electricity, was confirmed by a Bill, which passed the Committee of Ways and Means, presided over by Mr. Courtney.

Hartmann and Braun.—A comprehensive catalogue of electrical instruments has reached us from Messrs. Hartmann and Braun (for whom Messrs. O. Berend & Co., of Fore Street, act as agents), giving illustrations and prices of the great variety of measuring and testing instruments for which this firm has established a world-wide reputation.

Strike in Brussels.—The employés of the Société d'Electricité à Longue Distance, which has three stations in operation in Brussels, went out on strike on Thursday of last week. Several establishments were deprived of light, whilst others were able to rely upon gas. On Saturday the men resumed work, and lighting was recommenced.

Gent and Company.—Messrs. Gent & Co., of Leicester, publish an excellent price list of telephones, with which is incorporated all the necessary instructions for erecting lines and fixing and adjusting instruments. These are so fully explained by diagrams that any ordinary workman accustomed to bell hanging or plumbing would be enabled to carry out almost any class of telephone work. The illustrations are well done and the printing good.

Rashleigh Phipps and Dawson.—Messrs. Rashleigh Phipps and Dawson, of Berners Street, London, have just issued a new catalogue containing a second series of designs for electrical fittings. It contains 40 sheets of illustrations, beautifully printed in colours on enamelled paper by a process which very successfully conveys to the eye the actual appearance of the objects represented. As a catalogue to order from without seeing the goods themselves, this would be found a safe and reliable guide.

The Electric Lighting of Norwich.—The chairman of Ways and Means of the House of Commons (Mr. Courtney) presided on Thursday last week, at Westminster, over a committee on unopposed Bills, before which the Electric Lighting Provisional Orders (No. 2) Bill came. The measure confirms a provisional order of the Board of Trade with respect to the electric lighting of Norwich. It is unopposed, and after hearing formal evidence the committee approved it, and ordered it to be reported to the House for third reading.

The Electric Light at Dover.—The corporation at their weekly meeting on Tuesday, decided not to undertake the electric lighting of the town themselves, but to lease the concession to a company, with which object advertisements inviting tenders are to be issued. "We (*Dover Standard*) think the corporation has adopted a very wise course, for however desirable the electric light may be, it is more a matter of private speculation than for the town to incur the initial outlay. This course has been adopted by several other towns."

Argumentum ad Hominem.—The discussion on "Phenomena of Alternating Currents of very High Frequency," between Prof. Elihu Thomson and Mr. Nikola Tesla, which we publish this week, forms very interesting reading. The end of Mr. Tesla's third paragraph seems to have some bearing upon the experiments described by Mr. Gulstad in his article on "Electrostatic Induction."

Dewsbury Electric Lighting.—Mr. Courtney and the Ways and Means Committee had before them on Thursday the Bill confirming the provisional order of the Board of Trade under the Electric Lighting Acts of 1882 and 1888, authorising the corporation to undertake the electric lighting of the town. The committee passed the Bill. There was no opposition.

Appleton, Burbey and Williamson v. Mason.—A man trading under the name of Mason & Co., Queen Victoria Street, was charged at the Mansion House on Friday with obtaining goods from Messrs. Appleton, Burbey and Williamson on false pretences. It was held by the plaintiffs that upon the defendant representing he was a member of the Chamber of Commerce, goods were supplied to him. In the course of evidence it was shown that the defendant had been elected a member of the Chamber, but had failed to pay his subscription; this being the case, the Lord Mayor said nothing could be done, and the charge was dismissed.

Giraud's Thermo-Electric Stove.—Dr. Giraud writes to us that the figures which we gave, under reserve, concerning the yield of his most interesting apparatus are thoroughly exact. The results have been verified by M. Hospitalier and numbers of professors and engineers in Paris. The electric stove can actually furnish daily 45 watt hours × 24, but it is only warranted to give 40 watt hours, and if it does not come up to the guarantee the Doctor is willing to take it back, an act of fair dealing with which he does not credit many suppliers of electrical apparatus. The expense per day, he tells us, is 1 fr. 50 c. for producing nearly a kilowatt hour, and these figures are very significant to the consumer, who can supply his own electric lighting when at a distance from central stations for a price not much exceeding that of a public supply. Coal and coke can be found nearly everywhere, the stove furnishes the domestic heating, so, as the Doctor says, electric energy is really a bye-product, and he expresses his belief that before next winter the electric stove will be plentifully found in London and Paris. Naturally, by increasing the number of elements, Dr. Giraud can effect a larger output, and he is ready to produce a stove of 600 watt-hours. Moreover, the larger the stove the greater is the percentage of yield, and it is also easier to construct. It is likely that we shall see important improvements in this direction before the end of the year, but even as it is the work of Dr. Giraud seems highly promising, and we congratulate him on his encouraging success. We imagine that they will be mostly used in conjunction with accumulators, and it would be interesting, therefore, to know the cost price of a stove to give say 600 watt hours.

NEW COMPANIES REGISTERED.

Foreign and Colonial Arc Accumulator Company, Limited.—Capital £1,000, in £1 shares. Objects: To carry on elsewhere than in the United Kingdom the business of electrical engineers, electricians, contractors, and manufacturers of electrical apparatus for producing, storing, regulating, and supplying electrical energy, galvanism, and magnetism. Signatories (with one share each): H. B. Vorley, 38, Amherst Park, Stamford Hill, N.; H. Hill, 6, Harrison Road, Halifax; E. J. Pilcher, 47, Grange Road, N.; R. W. Blackwell, Buckingham Palace Hotel, S.W.; S. Morse, 4, Fenchurch Avenue, E.C.; J. Renwick, 58, Olinda Road, Stamford Hill, N.; T. T. Bickford, 39, Guildford Street, W.C. The regulations of Table A mainly apply. Registered on the 14th inst. by S. Morse, 4, Fenchurch Avenue, E.C. Office, 19A, Coleman Street, E.C.

Arc Accumulator Company, Limited.—Capital £1,000, in £1 shares. Objects: To carry on within the United Kingdom the business of electrical engineers, electricians, contractors and manufacturers of electrical apparatus for producing, storing, regulating and supplying electrical energy, galvanism, or magnetism. Signatories (with 1 share each), H. B. Vorley, 38, Amhurst Park, Stamford Hill; H. Hill, 6, Harrison Road, Halifax; E. J. Pilcher, 47, Grange Road, N.; R. W. Blackwell, Buckingham Palace Hotel, S.W.; S.

Morse, 4, Fenchurch Avenue, E.C.; J. Renwick, 58, Olinda Road, Stamford Hill, N.; T. T. Bickford, 39, Guildford Street, W.C. The regulations of Table A mainly apply. Registered on the 14th inst. by S. Morse, 4, Fenchurch Avenue, E.C. Office, 19A, Coleman Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Foreign Electric Date and Time Stamp Company, Limited.—The statutory return of this company, made up to the 21st ult., was filed on the 29th ult. The nominal capital is £100,000, in £1 shares. 36,507 shares have been taken up, upon 1,507 of which the full amount has been called and paid, and upon the remainder the full amount has been considered as paid. The total amount of shares, for which share warrants, comprising 16,500 shares each, are outstanding, is 16,500. Office, 90 and 91, Queen Street, Cheapside, E.C.

South Western District and Thames Valley Electricity Supply Company, Limited. — The statutory return of this company, made up to the 30th October, 1889, was filed on the 4th inst. The nominal capital is £100,000 in £10 shares. Seven shares have been taken up, but upon these no call has been made.

The first annual return of this company, made up to the 31st December, 1890, was filed on the 8th inst. No change has been made. Office, Battersea Foundry, Battersea, S.W.

LEGAL.

Action by the United Telephone Company.—In the Court of Session, Edinburgh, on Wednesday, evidence was heard in an action by the United Telephone Company, Limited, London, and the National Telephone Company, Limited, Oxford Court, Cannon Street, London, against Andrew Erskine Muirhead, merchant, Cart Forge, Crossmyloof, Glasgow, to (1) interdict the defender from infringing the pursuers' Edison and Morgan-Brown letters patents; (2) for payment of £500, and (3) for delivery or destruction of all instruments of which he is in possession which infringe these letters patent. It was stated by the pursuers in the petition that they were the owners of the patents, and they had discovered recently that the defender for some time past had been violating and infringing these letters patent. In particular, the defender had for some time prior to the 9th December, 1890, and also subsequent thereto, been supplying to parties and erecting telephone transmitters and receivers, known as Ader transmitters and receivers. These instruments are constructed according to pursuers' letters patent. In particular, the defender had supplied such instruments to Messrs. Merry and Cunninghame, ironmasters, Glasgow, and Messrs. J. and P. Coats, thread manufacturers, Paisley; the Central Agency, Glasgow, and to Mr. James Whyte, photographer, 37, Jamaica Street, Glasgow. The pursuers' trade had thus been interfered with and injured by the defender, and they have suffered to the extent of more than £500. The defender in his answer to the petition, admitted that with the knowledge and approval of the pursuers, he used Ader transmitters and receivers for experimental purposes, also that he had erected at the premises of Messrs. Merry and Cunninghame, and of Messrs. J. and P. Coats, Paisley, and at their Central Agency, Glasgow, telephone transmitters and receivers also for experimental purposes. He received no consideration whatever in respect of instruments so used and erected, nor had the pursuers been prejudiced thereby.

A minute was put in on behalf of the defender in which he admitted having supplied to certain firms—Messrs. Merry and Cunninghame and J. and P. Coats and John Chalmers—Ader and Berthon transmitters and Ader receivers; that these were supplied for the purpose of experiment during the currency of the pursuers' patents; that the Ader and Berthon were practically the same; that the sale of the Ader and Berthon transmitters was an infringement of the pursuers' second patent (the carbon transmitter), and that the sale of the Ader receiver prior to 9th December, 1890, was an infringement of the pursuers' first patent (the magnetic receiver.) On Tuesday, the defender in respect that one patent had expired and that the other would expire in July, offered to consent to the pursuers' obtaining interdict; to deliver to them infringing instruments in his possession, and to pay £50 damages and expenses as between party and party.

Mr. Graham Murray and Mr. Dickson, instructed by Messrs. Davidson and Syme, W.S., appeared for the pursuers, and Mr. Asher, Q.C., and Mr. Watt, instructed by Messrs. Clark and Macdonald, S.S.C., represented the defender.

After a good deal of evidence had been taken the case was accordingly settled on the footing that interdict was granted as craved, and £5 and costs as between party and party were paid to the pursuers. We shall publish a full report of this case in our next issue.

CITY NOTES.

The Consolidated Telephone Construction and Maintenance Company, Limited.

The directors, in submitting to the shareholders the report and accounts of the operations of the company for the year ending the 31st March, 1891, state that the latter shows a net profit of £11,573 8s. 9d., which, with the amount carried forward from last year, leaves a balance of £13,416 6s. 8d. for disposal, after making provision for doubtful debts.

The directors propose to deal with this amount as follows, viz., to pay a further dividend of £7 per cent for the half-year on the ordinary shares, and £6 per cent. on the preference shares, making, with the interim dividend paid in November last, £6 per cent. for the year on both descriptions of shares; writing off the sum of £530 3s. for depreciation of plant, machinery, and furniture £63 16s. 8d. from cost of new building, and the sum of £436 from good will and patent rights, thus leaving a balance of £1,716 4s. 10d. to carry forward.

The lawsuit in Belgium, relating to the patents in which the Edison-Gower Bell Telephone Company is interested, is still in the hands of the solicitors, but it is hoped that a decision will soon be arrived at.

One of the patents for telephones held by the National Telephone Company expired on the 9th December last. This has had the effect of enabling the Consolidated Company to sell telephones to the public; and, so far as your board can judge, an increasing business is in prospect. The shareholders may rely upon every effort being made to keep the company's manufactures well in advance of both home and foreign competition.

The subsidiary companies continue to make most satisfactory progress, as is shown by the following statement:—

	Year ending 31st March.					
	Subscribers.		Rental.		Increase.	
	1890.	1891.	1890. £	1891. £	Subs.	Rental. £
Telephone Company of Austria	2,868	3,263	18,100	20,500	395	2,400
Anglo-Portuguese Telephone Company ...	1,915	2,074	12,232	13,458	159	1,226
	Total increase for the year				554	3,626

In accordance with the articles of association, the following directors retire by rotation, and, being eligible, offer themselves for re-election, viz., Sir Alexander Armstrong, K.C.B., &c., and Arthur Henry Baker, Esq.

The auditors, J. G. Griffiths, Esq., F.C.A. (Messrs. Deloitte, Dever, Griffiths & Co.), and A. E. Green, Esq., F.S.A.A., also retire, and offer themselves for re-election.

Revenue Account for the year ending 31st March, 1891.

Dr.	£	s.	d.
To General Expenses of Management—Including salaries, directors' remuneration, office expenses, stationery, and printing	2,558	16	7
" Auditors' fees	105	0	0
" Travelling expenses	53	15	11
" Income tax on profits	215	3	6
" Legal expenses	21	1	10
" Payments in respect of patents	189	10	0
" Expenses in connection with Belgian patents ...	150	0	0
" Expenses in connection with Edinburgh Exhibition...	41	15	0
" Expenses in connection with issue of preference shares	183	4	0
" Balance carried down	11,573	8	9
	£15,091	15	7

Cr.	£	s.	d.
By Profit on manufacturing	9,619	1	3
" Interest on debentures—Telephone Company of Austria	1,681	17	6
" Dividend on preference shares—Telephone Company of Austria	573	13	9
" Dividend on ordinary shares—Telephone Company of Austria	414	8	0
" Interest on 6 per. cent. debentures—Anglo-Portuguese Telephone Company	117	0	0
" Interest on 8 per cent. debentures—Anglo-Portuguese Telephone Company	253	10	0
" Dividend on preference shares—Edison Gower-Bell Telephone Company of Europe	1,500	0	0
" Dividend on shares—National Telephone Co. ...	233	12	11
" Dividend on ordinary shares—United River Plate Telephone Company	50	0	0
" Interest (general)	622	19	8
" Transfer fees	25	12	6
	£15,091	15	7

Dr.	£	s.	d.
To Depreciation—			
Amount written off goodwill and patent rights	436	0	0
Do. do. Cost of new building	63	16	8
Do. do. Plant and machinery	518	4	0
Do. do. Furniture	11	19	0
„ Interim dividend on ordinary shares, paid Nov., 1890	3,836	10	1
Do. on 6 per cent. preference shares	731	5	0
„ Balance carried down	7,818	11	11
	£13,416	6	8

Cr.	£	s.	d.
By Balance carried down	11,573	8	9
„ Balance of revenue account from 31st March, 1890	1,842	17	11
	£13,416	6	8
By Balance	£7,818	11	11

Balance Sheet, 31st March, 1891.

Dr.	£	s.	d.
To Authorised Capital—			
75,000 6 per cent. preference shares of £1 each...	75,000	0	0
224,850 Ordinary shares of 14s. each	157,395	0	0
75,150 Ordinary shares of 20s. each	75,150	0	0
375,000	£307,545	0	0
„ Capital Issued—			
25,000 6 per cent. preference shares of £1 each, fully paid	25,000	0	0
224,850 Ordinary shares of 14s. each, fully paid	157,395	0	0
„ Sundry creditors and credit balances	1,669	8	10
„ Sundry shareholders for Unclaimed dividends and returned capital	191	3	2
„ Revenue account, balance of net profit to date ...	7,818	11	11
	£192,074	3	11

Cr.	£	s.	d.
By Capital Expenditure—			
Goodwill, patent rights, &c., less written off (£436)...	73,000	0	0
Note.—The company has conceded patent rights to subsidiary companies, and holds in respect thereof the following shares, viz.:— Edison Gower-Bell Telephone Company of Europe, Limited, 174,995 shares of £1 each.. £174,995 Telephone Company of Austria, Limited, 5,667 shares of £5 each 28,335 £203,330			
Plant and machinery, less depreciation (£518 4s.)	4,663	15	6
By furniture, less depreciation (£11 19s.)	107	11	3
„ New building, less written off (£63 16s. 8d.) ...	319	3	4
„ Stock of instruments, materials, stores, &c. ...	6,895	16	0
„ Debtors subsidiary companies, other companies, and persons, less reserves (£150)	8,843	3	5
„ Sundry differences in income tax	0	12	5
„ Investments in telephone companies	86,562	14	7
„ Loans on security	6,600	0	0
„ Cash at bankers and in hand	5,081	7	5
	£192,074	3	11

West Coast of America Telegraph Company.

The fourteenth ordinary general meeting of the shareholders of this company was held on Friday at Winchester House, Old Broad Street, Mr. Alfred Marshall in the chair.

The **Chairman** said although they had not earned such large receipts as in 1889, still the receipts might be considered satisfactory. The only item that called for explanation was that of the gross earnings, which, although nearly the same as 1888, fell short of 1889 by £20,000. This was to be accounted for by the repairing steamer earning £5,400 less than in the previous year, owing to their neighbours having built and used their own steamer, instead of using theirs, and by their having earned much less in messages between Europe and the East Coast of South America, because there had been no repetition of the interruption on the Eastern line during 1889, which gave this company such exceptionally large traffic during that year. There was an increase of £1,000 in the interest account which was due to large investments in the reserve fund. The negotiations referred to in the report were progressing favourably, and he had great confidence in their resulting in placing this company in a better position than before to cope with and resist competition. After alluding to the interruption in the cable service, owing to the revolution in Chili, he remarked that from the latest advices they had received it appeared that the greater part of the disturbed service was now in operation, and they had been compensated by the Chilian Government for having had their cables taken over. He moved the adoption of the report.

Mr. **Henry Roberts** seconded the motion, which was agreed to.

The retiring directors and auditors were re-elected.

The Western Counties and South Wales Telephone Company.

The sixth annual meeting of the shareholders in the Western Counties and South Wales Telephone Company, Limited, was held on Friday last at the Grand Hotel, under the presidency of Mr. Charles Nash. The report of the directors, which has been given in the Review, was taken as read.

The **Chairman**, in moving the adoption of the report, dealt with the question of capital expenditure. He then spoke of several points in the report bearing on the increase in the number of subscribers, the increase in wire mileage, and the increase of trunk messages, and contended that those facts pointed conclusively to the steady and continuous progress of the company. Having alluded at length to their trunk system and its working, he said he hoped they would agree with him that the considerable outlay of £46,883 on trunk lines had been fully justified by the results. He found that between Cardiff, Newport, and Swansea there were in April 13,384 calls, and as each call was answered, the total communications were 26,768, or more than 1,000 a day for the 26 working days of the month in that district alone. During the past year their trunk system had been extended *via* Gloucester and Worcester, to Birmingham and the Midlands and the North of England. In the local exchanges he found that there was an increase of more than half a million calls in 1890 over 1889, and as each call was answered, more than six million communications were made. Not only was the business continuous, but it was going on more rapidly than ever; and, considering the near expiration of patents and the rumour of competition, this fact was a striking proof of the firm hold that the telephone had on the public mind. Eighteen weeks of the current year had passed, and in that time they had an increase of £1,845, against £1,504 in the corresponding period of last year, which showed a large weekly increase. Such continued and increasing advance was most satisfactory. There was another point, and that he thought was a very important one. The greater part of their agreements were for long periods, and had a considerable unexpired time to run. From a carefully prepared table, he found that at the end of last November they had 1,104 agreements for the year, and 2,141 for periods ranging from one to nine years. These unexpired periods of agreements represented on the 30th of November last a contract rental to the amount of between £86,000 and £87,000 constituting an element of great stability to the company. These agreements had been secured by charging lower rates for the longer periods. They would agree with him that, in case of a purchase by the Post Office or the National Company, these long unexpired agreements, and the great general elasticity of their business, would constitute important elements of value. It only remained for him to state that one of their patents expired last December, and that the other would run out on the 31st July. This would relieve them from the payment of a considerable amount of royalty; and without committing themselves then to any precise figures, he might say that it was their intention to reduce the rates payable by their subscribers to at least the amount of the remission of the royalty, and they hoped that the reduction would lead to a considerable increase of business. This reduction would probably take effect from the 1st of August.

Mr. **Mark Whitwill** seconded the adoption of the report, remarking that the figures quoted that day proved conclusively that what they said years ago was true, that business people would gradually begin to appreciate the advantages of the telephone.

In reply to a question why the directors had not thought it right to declare a dividend on ordinary shares,

The **Chairman** said the directors did propose a dividend of ½ per cent.; but on consulting the members of the board in London, they took a different view and declined to sanction the dividend being made; therefore they had no choice but to give way, as the voting power of the directors in London was so large.

The report was then adopted.

Panulcillo Copper Company.

Sir John Pender, presiding at the ordinary general meeting of the company, said:—"The other day, when I was addressing a large meeting of shareholders of the Metropolitan Electric Light Company, I had occasion to point out that during the fifteen months of that company's existence it had put down 90 miles of insulated copper wire, and when we look at the large number of similar companies springing up, not only in London, but in every important town in this and other countries, it will give you some idea of the large quantity of copper that is being used, and will eventually be used for electric lighting purposes. We are also encouraged by the fact that the sulphate of copper, which is being largely used for destroying insects, not only in vines, but in general agriculture, is likely to prove a success."

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ended May 15th, 1891, amounted to £5,176.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 15th, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Company, were £4,170.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (May 14.)	Closing Quotation. (May 21).	Business done during week ending May 21, 1891.	
					Highest.	Lowest.
250,000*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	...	...
1,381,380*l*	Anglo-American Telegraph, Limited	Stock	47 — 48	46½— 47½	47½	47
2,809,310*l*	Do. do. 6 p. c. Preferred	Stock	85— 86	84 — 85	86	85
2,809,310*l*	Do. do. Deferred	Stock	12 — 12½	11½— 12	12	11⅝
130,000	Brazilian Submarine Telegraph, Limited	10	11¾— 12¼	11¾— 12¼	12 1/16	11⅞
84,500*l*	Do. do. 5 p. c. Bonds	100	101 —104	101 —104	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	104 —108	104 —108	...	...
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416	3	2⅛— 2⅜	2¼— 2½	...	...
63,416	Do. do. Non cum. Preference, Nos. 1 to 63,416	2	1⅝— 1⅞	1⅝— 1⅞	...	...
50,000	City and South London Railway, Nos. 1 to 50,000	10	5 — 6	5½— 6½	...	...
$7,216,000	Commercial Cable, Capital Stock	$100	108 —110	108 —110	...	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	14/-	½— ⅝	½— ⅝	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Preference Shares, Nos. 1 to 20,000	Stock	4 — 5	4 — 5	...	...
16,000	Cuba Telegraph, Limited	10	10½— 11½	10½— 11½	...	...
6,000	Do. do. 10 p. c. Preference	10	16½— 17½	16½— 17½	17	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼	...	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10	...	...
60,710	Direct United States Cable, Limited, 1877	20	10¼— 10½	10¼— 10½	10⅝	10 5/16
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅜— 14⅝	14⅜— 14⅝	14 9/16	14⅜
70,000	Do. 6 p. c. Preference	10	15¼— 15¾	15¼— 15¾	15⅝	...
200,000*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	...	...
1,200,000*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	106 —106	106 —109	108¾	107½
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14¾— 15¼	14¾— 15¼	15⅛	15
91,800*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	103 —106	103 —106	...	...
325,200*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	103 —106	103 —106	...	...
320,000*l*	Do. 4 p. c. Debenture Stock	Stock	105 —108	106 —108	107	...
135,000*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	103 —106	103 —106	...	...
180,400*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	103 —106	103 —106	105½	...
201,600*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	99 —101	99 —101	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	5 — 6	5 — 6	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4½— 5	4½— 5	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	1⅜— 1⅝	1⅜— 1⅝	1⅜	...
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	2 — 2½	2 — 2½	2½	2 1/16
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1 — 1½	1 — 1½	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 only paid)	5	2½— 3½	2½— 3½	...	...
180,227	Globe Telegraph and Trust, Limited	10	9¼— 9½	9¼— 9½	9½	9⅜
180,042	Do. do. 6 p. c. Preference	10	14⅞— 15⅛	14⅞— 15⅞	15 1/16	14¾
150,000	Great Northern Tel. Company of Copenhagen	10	18 — 19	17½— 18½	18½	18
230,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	105 —108	105 —108	...	...
9,334*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	10 — 11	10 — 11	...	...
5,334*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11 — 12	11 — 12	...	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited ...	10	18½— 19½	18½— 19½	19½	19¼
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	102 —104	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	39 — 41	39 — 41	39	...
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	7½— 8½	7½— 8½	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9¼— 9¾	9¼— 9¾	...	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6½— 7½xd	6½— 7½xd	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	106 —109	106 —109	...	...
43,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	9 — 9½	9 — 9½	9⅛	...
438,984	National Telephone, Limited, Nos. 1. to 438,984	5	4¼— 4½	4⅝— 4⅞	4 11/16	4⅝
15,000	Do. 6 p. c. Cum., 1st Preference	10	12¾— 13¼	12½— 13	...	...
15,000	Do. 6. p. c. Cum. 2nd Preference (£8 only paid)	10	12 — 12½	12 — 12½	...	...
350,000	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	102 —104	103 —105	104	103¾
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	¼— ⅜	¼— ⅜	...	...
9,000	Reuter's Limited	8	8 — 8½xd	8 — 8½xd	8½	...
209,750	South of England Telephone, Limited, Ordinary Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼	...	...
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	3 — 3½	3 — 3½	...	...
3,381	Submarine Cables Trust	Cert.	113 —118	116 —121	...	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	4½— 5 xd	4½— 5 xd	...	...
37,350	Telegraph Construction and Maintenance, Limited	12	45 — 47	46 — 48	47	45½
150,000*l*	Do. do. do. 5 p. c. Bonds, red. 1894	100	102 —105	102 —105	...	...
58,000	United River Plate Telephone, Limited	5	2½— 3½	2½— 3½	...	...
146,128*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	85 — 95	85 — 95	...	...
3,200*l*	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8 — 9	...	...
290,900*l*	Do. do. do. 5 p. c. Debentures	100	97 —100	96 — 99	96½	...
30,000	West Coast of America Telegraph, Limited	10	3½— 4½	3½— 4½	...	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	97 — 102	100 — 105	...	...
64,174	Western and Brazilian Telegraph, Limited	15	11 — 11½xd	11 — 11½xd	11 5/16	...
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6½— 7 xd	6½— 7 xd	...	...
27,873	Do. do. do. 5 p. c. Deferred	7½	4¾— 5¼xd	4¾— 5¼xd	4¾	...
200,000*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
250,000*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	...	...
88,321	West India and Panama Telegraph, Limited	10	3⅛— 3⅜	2⅞— 3⅛	3⅛	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11¾— 12¼	11¾— 12¼	...	...
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	11½— 12½	11½— 12½	...	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	117 —122	117 —122	...	...
175,100*l*	Do. do. 6 p. c. Sterling Bonds	100	100 —104	100—104	...	...
42,853	*Westminster Electric Supply Corporation, Ord., Nos. 101 to 42,953	3	4¼—5¾	4¾— 5¼	...	...

* Subject to Founders' Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7¼—7⅝.—City of London Electric Lighting (Pioneer), Shares of £50, £25 paid, 32—34.—Elmore's Austrian Copper Depositing, 15s., 25s.—Elmore's Priorities, 3⅞—4⅛.—House to House Company (£5 paid) 4¾—5¼.—Liverpool Electric Supply, £3 paid, 2⅝—2⅞.—London Electric Supply Corporation, Ordinary (£5 paid), 2⅛—2⅝.—Manchester, Edison and Swan Company, £9 (£1 paid) 2s 6d.—5s.—St. James's and Pall Mall Electric Light £5, 5⅞—6⅛.—St. James's and Pall Mall, 7 per cent. pref., ⅝ to ⅞ prem.—Woodhouse and Rawson Ordinary of £5 (£2 10s. paid), 2—2½.—Preference, fully paid 3⅞—4⅜.—Debentures 90—95.—Woods Electric Car, £10 paid, ¾—1.

BANK RATE OF DISCOUNT.—4 per cent. (7th May, 1891).

ELECTRICITY IN THE PRODUCTION OF ALUMINIUM.[*]

By ALEXANDER S. BROWN.

The glamour that has surrounded this metal since 1856, when H. St. Claire Deville first obtained it in sufficient quantities to study its physical and chemical characteristics, and the almost monthly presentation before one or another of our scientific societies of papers treating of its properties, &c., makes it a most difficult subject to handle with originality. Scientific and newspaper eulogists have expended a great deal of time and many words in extolling the unusual combination of useful properties which it possesses, and have given their imaginations full play in describing its future triumphs in the metallurgical world; but as yet little has been actually accomplished in the way of accurately determining the commercial status and mechanical value of this metal compared to others more familiar to us. While it must be confessed that in certain respects its merits seem such as to warrant great expectations, those interested in its production and its commercial success have experienced not only the usual difficulties inseparable from the introduction of any new metal, but many others due to the too great esteem which the public has been led to bestow upon it. When sufficient knowledge of its characteristics has been acquired to form an unbiased judgment as to its true rank in the metallurgical world, there is little doubt it will be found to be one of the most useful metals ever discovered, and that it will not only largely displace copper, but will make for itself new and important fields of usefulness.

Still, of all the metals commercially familiar to us, aluminium has unquestionably made the most rapid progress. The long and tedious development of iron, steel, copper, tin, lead, zinc, &c., extending over centuries and centuries, is familiar to us all; the fact that this new metal (only discovered in 1827, and extracted in perceptible quantities not earlier than 1854) has already entered into commercial competition with the oldest and most useful metals, substantially at their own prices, would alone make aluminium a most interesting subject of study and speculation.

In the year 1760, or thereabouts, a chemist named Morveau, by calcining alum obtained a substance which he called alumina. Shortly thereafter Lavoisier suggested the existence of metallic bases in the earths and alkalies, and, naturally, alumina was immediately suspected of being a metallic oxide. Some interesting speculations were indulged in on this subject, and this hypothetical metal received the name of aluminium.

As early as 1807, Davy and others tried ineffectually to decompose alumina by various means, including the use of the electric current. A chemist named Oerstedt thought he had produced the metal in 1824, but a German chemist named Wohler was the first to actually demonstrate its existence. He extracted the metal in 1827 by decomposing the chloride of aluminium by means of metallic potassium; 20 years later he also reduced it with metallic sodium. The first commercial product was exhibited in 1854 by H. St. Claire Deville, a French chemist, whose researches as to its chemical and physical properties (fully reported in the French journals of the day), were so thoroughly exhaustive, that his writings are still standard authority on the subject. He used several methods, the most successful of which was reduction by sodium. Patronised by Napoleon the Third, who entertained great expectations concerning the use of this metal in war equipment, Deville established commercial works near Paris, which, after varying fortunes, were finally permanently located at Salindres, France, and these works for many years produced substantially all the pure aluminium consumed in the world. It may interest you to know that up to 1886 the annual production of this metal was less than 10,000 lbs., of which 6,000 to 8,000 lbs. were produced in France. In 1860 it sold at over $90 per lb. In 1887 it was sold at $5 per lb., and is now selling at $1 for a commercially pure article—this term signifying about 97 per cent. purity in the metal. It is known that by processes now in operation, the metal can be produced in large quantities at a price which will put it on a par with copper, bulk for bulk.

Until the dynamo came into commercial use the production and development of aluminium was almost entirely along chemical lines. It is a metal that possesses remarkable affinity for oxygen and chlorine, and, so far as I know, only potassium and sodium are capable of extracting oxygen and chlorine from it on a commercial scale. Naturally, therefore, the history of its progress is interwoven with that of the commercial manufacture of sodium and potassium. As early as 1856, one Mons. Alfred Monier, of Camden, N.J., claimed to have successfully made sodium by a continuous process, as a preliminary step in the manufacture of aluminium, and, later, he exhibited several small specimens at the Franklin Institute. This is undoubtedly the earliest record of the production of aluminium in this country.

Three years later, in 1859, the first aluminium works in England were started at Battersea, near London, but no details concerning them are obtainable. In 1860 other works were successfully established at Newcastle-on-Tyne, by Bell Bros., which were operated with more or less success until 1874. These gentlemen seem to have been close investigators of the subject, and have published important information concerning the characteristics of this metal. Other spasmodic attempts to establish aluminium works were made in Germany and other countries, but it may be truthfully said that France, which created that industry, remained its home until the development of the electrical processes which have now superseded all others. The most important effort on this line was that of Mr. James Webster, who, in 1882, re-established the aluminium industry in England, forming the Aluminium Crown Metal Company at Hollywood, near Birmingham. The principal features of his patent, which this company operated, were the large cheapening of the manufacture of alumina (Al_2O_3). He claimed to obtain a product containing about 84 per cent. of alumina—a substantial gain upon other known processes—and also to save half the cost of manufacture by utilising by-products. In fact this company was for several years a successful competitor in the English markets to the French works at Salindres, though its output was very limited.

About 1886 a young Philadelphian—Mr. H. Y. Castner—invented and secured a number of patents to cover an improved and economical method of making sodium, which he claimed reduced its cost to 25 cents per pound. This invention he took abroad, and in 1887 the Aluminium Crown Metal Company was re-organised under the name of the Aluminium Company, Limited, and extensive works for the manufacture of sodium, primarily, and of aluminium, secondarily, were erected at Oldbury, near Birmingham. They were completed in July, 1888, and were alleged to have a very large capacity for producing aluminium. The reduction of aluminium at these works was conducted strictly on the lines of Deville's process—Castner's improvements being solely in the cheapening of sodium—and came to be known as the Deville-Castner process. Considerable quantities of metal were produced at these works, and most of it was of exceptional purity. As long as aluminium ruled above $3 a pound, they were commercially successful; but inasmuch as it takes nearly 3 lbs. of sodium to make one of aluminium and the various other steps in the reduction are rather expensive, this process has not been able to compete commercially with the less costly electrical processes, and the Oldbury works are now devoted exclusively to the manufacture of metallic sodium, which finds profitable markets in Germany and elsewhere, being largely used in the chemical manufacture of antipyrene.

During the development of the various sodium processes to which I have above referred to, the possibility of utilising electricity was not neglected. Among the earliest patentees in this field were Camille A. Faure, in 1880-4, and R. Gratzel in 1883. Other inventors before those dates realised the value of electricity in smelting and other electro-chemical processes, but they were the first to give practical direction to theoretical speculation. Nothing has recently been heard of Faure's process, but that patented by Gratzel in Germany, in 1883, was practically utilised by a firm at Hemelingen, near Bremen, called the Aluminium and Magnesium Fabrik. The Gratzel process consisted, substantially, in electrolysing a bath of fused chloride or fluoride of aluminium by means of anodes composed of a mixture of carbon and alumina, the current being furnished by a dynamo, but for some reason it was abandoned by the company in 1887 for another process, the nature of which has been kept a profound secret.

Between 1883 and 1886 a number of inventors secured patents for electrical processes, but I need only mention those which, in the struggle for the survival of the fittest, have come into commercial prominence.

On April 2nd, 1889, Mr. Charles M. Hall, of Oberlin, Ohio, secured patents for a process of reducing pure aluminium. In this process alumina is dissolved in a fluid bath composed of aluminium fluoride and potassium fluoride, with, perhaps, an addition of lithium fluoride, this bath then being electrolysed by means of an electric current conveyed to a carbon-lined furnace through an anode of some non-carbonaceous material. In electrolysing this bath, the containing vessel is made to serve the purpose of the negative electrode. In another patent Mr. Hall claims the use of a bath composed of alumina dissolved in compound fluorides of aluminium with alkaline earthy metals, and in still another patent, the use of a bath composed of alumina dissolved in the fluorides of aluminium, calcium, and sodium; these materials being obtained by melting together aluminium fluoride, fluorspar, and kyrolite. With this latter bath a carbon anode can be used without the bath being affected by its disintegration.

The Hall group of patents is now controlled by the Pittsburg Reduction Company, of Pittsburgh, Pa., which has had its metal on the market since March, 1889. The plant has a daily capacity for producing about 300 pounds of metal, the selling price of which was $2.00 per pound, until the early part of March last, when it was reduced to $1.00 per pound for commercially pure aluminium, of a guaranteed purity of 97 per cent. The reduction in price, considered in conjunction with the limited amount of pure metal produced, would appear to confirm the generally received impression that while the pure metal is specially adapted to the manufacture of articles of art and ornament, it is not displacing tin, platinum, silver, &c., to anything like the extent its admirers have supposed it would. The fact is, aluminium as a pure metal is not destined largely to supplant other metals in the arts and manufactures; it is to its alloys that we must look to redeem the inflated reputation of the pure metal. The true value and use of aluminium seems to have been forecast by Deville, who predicted for it an intermediate position between the precious and baser metals, in which relation to manufactures he said it was destined to fill a long-felt and important want. He doubtless referred to the pure metal, but, curiously enough, his prediction applies with greater force to its alloys, which have been demonstrated by actual use and thorough tests to possess physical and chemical properties that place them above all other alloys of copper, iron, and in some instances even of steel.

The electric smelting process of the Messrs. Cowles, of Cleveland, Ohio, was the first to secure a commercial footing in this country. These gentlemen have taken out a series of patents covering their process, and they have exhibited very commendable energy and perseverance in establishing a market for their products. Both the process itself and apparatus used have been so frequently and minutely described that they are doubtless familiar to all of you, and a recapitulation of its details in this paper would be superfluous. As defined in numerous papers and publications emanating from, or inspired by, the inventors, the process may be described as the reduction of metals by smelting their ores with heat produced by the passage of an electric current through broken resistance material—that is, in the presence of an incandescent material (carbon being generally preferred). Stress is laid on the alleged fact that the reduction is purely and solely a smelting operation, due to a heat far greater than can be obtained by any agency other than the electric current. The electrical (chemical) effect of the current is distinctly disclaimed in their patents and publications. Perhaps I may not unprofitably consume a moiety of your time by explaining that the furnaces used at the company's extensive works at Lockport, are rectangular and oblong in shape, comparatively shallow, and are composed exteriorly of walls of fire-brick or metal, lined with pulverised charcoal or other form of carbon or similar material, of electrical conductivity inferior to the ore to be smelted; this material being generally previously saturated with lime water to increase its resistance to heat. At each end of these furnaces are inserted rods of carbon which, passing through the walls and linings, are brought very nearly into contact within the body of the furnace, and, being connected to suitable wires or cables coupled to the dynamo, constitute the positive and negative electrodes. The charge consists, ordinarily, of a mixture (in different proportions) of an electrically resisting material—such as electric light carbon—and the ore to be reduced; though (in cases where the ore itself has sufficient electric resistance) the carbon is sometimes dispensed with. The charge fills the furnace and presses against the sides and ends of the electrodes which project into the furnace. When a current of electricity is passed, the electrodes are so adjusted as to form an arc, and the current then flows from the sides and ends of the electrodes through the broken resistance material, which, of course, becomes incandescent, and the intense heat developed by this incandescence reduces the ore; the metal flowing to the bottom of the crucible and being subsequently tapped or dipped out when the charge is consumed. The gases liberated in the operation pass out through openings in the fire brick cover of the furnace. From the character of the apparatus and manufacture or operation described, it will be obvious to you that the reduction of the metal is (as claimed by the Cowles Company) accomplished by means of heat generated by the passage of an electric current through a mass of high resistance material, and that if the chemical effect of the current assists the reduction at all, such utilisation is entirely accidental and unsought. Neither aluminium nor any other metal is produced on a commercial scale by this process *as pure metal*.

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[*] A paper read at the 56th meeting of the American Institute of Electrical Engineers, New York, April 21st, 1891.

The principal rival to the Cowles process for producing aluminium alloys is the Heroult process, which produces aluminium and other metals from their refractory ores in the presence of another alloying metal, and is contradistinguished from the Cowles process mainly by the fact that it operates exclusively—or at least almost extirely—by utilising the chemical or electrolysing action of the current. This process is the invention of a young French electrical engineer named Paul L. T. Heroult, whose affiliations with the firm of Messrs. Henry Merle & Co., owning and operating the Deville Aluminium Works at Salindres, and his subsequent studies at the Polytechnic Schools at Paris and Switzerland, first directed his attention to the electrical reduction of aluminium. In 1886-7 he secured French, English and other European patents, covering several processes for the extraction of aluminium, silicon, boron, &c., from their ores, both as pure metals and in the form of alloys. On August 14th, 1888, he secured a United States patent, No. 387,876, for the process of preparing aluminium bronzes and their alloys, and it is understood has pending in the Patent Office a series of applications covering other parts and features of his inventions. Though the Heroult processes have been very little discussed or even described in print, and are therefore almost wholly unknown to the public, their commercial success abroad has been far greater than has attended any other aluminium process, and while those owning the American patents seem as yet to have done little in the way of exploiting them, the success of a small plant put into operation at Boonton, N.J., for private demonstration purposes, in April, 1890, has been such as to give it rank among the prominent aluminium processes in this country. Having had exceptional facilities for studying the workings of this plant during the past four months, I might be pardoned—especially as so little is publicly known of it—for describing it at length, but as I particularly desire in this paper to direct your attention to the electrical apparatus used at Boonton, by way of illustrating the great power and value of the electric current in metallurgical operations, it will suffice here to say that the patents of this young engineer, having first been acquired by Swiss capitalists, were afterwards bought by the celebrated syndicate which, under the name of the Allegemeine Electricitats Gesellschaft of Berlin, substantially controls the entire electrical field in Germany. This syndicate, after carefully examining all other processes then known, invested 10 millions of francs in the Heroult process, and are operating very extensive works, which obtain their power from the falls of the Rhine at Schaffhausen. There they produce not only pure aluminium and all its alloys, but also alloys of silicon and other metals. Those works are supplied partly with dynamos of the type I wish especially to describe to you, and partly with dynamos of 600 electrical horse-power, a complete description of which I regret I am not able to place before you at this time, as they would interest you. These machines, weighing over 50 tons each, revolve horizontally; they have 24 pole-pieces with collectors over 12 feet in diameter, and were especially designed for economical work.

To give you a comprehensive idea of the method employed by Mr. Heroult in manufacturing aluminium and its alloys—and so far as electrical apparatus is concerned, there is little difference between his and the Cowles process—it will be best to describe the electrical plant and crucible separately.

In the electrical apparatus the most important feature, of course, is the dynamo which generates the current. This machine was designed by Mr. C. E. L. Brown, of the Oerlikon Works, Zurich, specially for electro-metallurgical work, and is the only one of its kind in America. It weighs, complete, over 19 tons, and when driven at 220 revolutions generates a current of 35 volts and 3,500 ampères. It is a 6-pole machine; having an armature of Gramme ring type, and the current is taken off commutators at either end by 72 brushes. The armature is 39 inches in diameter, and the shaft (including its clutch) is 11 feet 7 inches long. The commutators are each 19 inches in diameter and 20 inches long; each commutator containing 60 segments weighing 13 lbs. apiece, or a total of 780 lbs. for the segments for one commutator alone. The core of the armature consists of a very large number of sheet iron discs clamped together in a frame of aluminium-bronze. About ⅜ of an inch from the outside edge of the core, 120 holes pass from one end to the other, through each of which passes a copper wire ½ inch in diameter. These wires, which of course are thoroughly insulated from the core, form part of the winding. The remainder of the winding is composed of copper bars ¼ of an inch thick, 31 inches long and 2¼ inches wide. Though, as previously mentioned, the works at the Rhine Falls are in part equipped with much larger dynamos of 600 electrical horse-power, it has been found that they do not give nearly as economic results as the other dynamos of the kind I have attempted to describe. This latter type is also in universal use at Mr. Heroult's own works at Froges, France. At the time a friend visited the Schaffhausen works last summer, one of these 150 horse-power machines had been running without a moment's intermission five months, and another nearly four months. Though rated at 150 horse-power by the Swiss makers, the same machine in this country would be rated at over 200 horse-power, and would be driven at much greater velocity. In actual work they are frequently run up to 300 revolutions, and though it sometimes happens in practical operations that heavy short circuits occur, there is hardly any perceptible sparking at the brushes, even when the current rises to 8,000 or more ampères. The indicator attached to two of these machines (coupled in series) at the Rhine Falls has frequently recorded 25,000 ampères without any evidence of the short-circuiting appearing at the brushes.

At the Rhine Falls, at Froges, and at Boonton, these machines are coupled directly to turbine wheels arranged upon horizontal shafts. The frame to which the field magnets are attached is a solid casting, weighing alone over 9 tons. The field magnets are excited by a smaller dynamo driven by belting from a pulley on the main shaft. This smaller machine was also designed by Mr. C. E. L. Brown, the armature being similar to that of the large machine, except that it has but one commutator. This exciting machine is run at 60 volts and 120 ampères, and its performance is worthy of all praise.

At Boonton the leading wires are eight in number, four positive and four negative; each wire being square, and having a cross section of one inch. They are, in fact, rolled copper bars, uninsulated, because the low potential of the current requires no special insulation. An ammeter is placed in the main circuit by a simple arrangement for the guidance of the workman who specially looks after the crucible. The distance from the dynamo to the furnace (which is situated in another room) is only 14 feet. The four positive wires pass directly to the clutch which holds the anode, and the four negative wires pass from the ammeter back to the dynamo.

The crucible is composed of a strong iron box, which has a deep lining of carbon, previously ground very fine, mixed with sufficient tar, and thoroughly compacted on the bottom and around the sides of the containing iron box. After the furnace is thus re-lined, the carbon is baked, in order to drive away the tar and harden the lining. The position of this crucible is directly the reverse of those used by the Cowles Company, and that the carbon crucible itself actually forms part of the electric circuit. Unlike the Cowles process, Heroult's is a continuous process; the reduced metal being tapped from the bottom of the crucible, while the machine is merely stopped or slowed down for a few minutes. The interior dimensions of the crucible varies with the ore to be reduced, and the size and character of the anode used. Ordinarily it has an interior depth of about 22 inches, and a clear space of 6 inches between the walls and exterior surface of the anode. The electric current passes into the crucible through the suspended carbon anode, the vertical position of which is controlled by an attendant who lowers it from time to time to preserve an approximately constant distance between the bottom of the anode and the surface of the molten bath in the crucible. The anode usually dips several inches into this molten bath and in practice the intervening space between its bottom and the surface of the molten metal, is kept at about an inch by the attendant who by watching the needle of the ammeter is enabled to maintain the electrode in its proper relative position without difficulty. In order to get as perfect a contact as possible between the furnace and the cables leading therefrom back to the dynamo, the cables are firmly clamped to a large block of zinc, which projects from the rear of the furnace and is kept cool by water circulating in pipes around which the zinc is cast. While, properly speaking, the crucible has no top, as a rule plates of carbon imbedded in dry alumina spread over the top of the crucible are so adjusted as to fit close to the anode in order to retain most of the heat. The mouth of the crucible is formed of slabs of carbon built up funnel shape. The hearth or floor is pierced by a tap hole, which is kept closed by a plug of carbon or fire-clay, and is opened from time to time to allow the molten metal to run into a carbon-lined ladle, from which it is cast into ingots.

There are a few distinctive but not important differences between Heroult's method of making alloys and reducing pure metals simply. In making alloys, the base alloying metal is first melted in the crucible by the current, or molten meltal is poured into the furnace to form a liquid metallic cathode. This is usually simply and economically accomplished by throwing pieces of the metal—copper, for instance—into the furnace, seating the anode upon them and passing the current. At first the current is very unsteady, arcs constantly forming between the copper and the anode, but when the copper is entirely melted (and it takes but a very few minutes to melt 200 or 300 lbs.) the ore to be reduced is added in sufficient quantities to form a bath, and floats on top of the molten copper. The anode having been raised so as to leave a space of about an inch between its bottom and the molten copper, the current becomes steady, and the operation is established. Thereafter the ore is introduced in small quantities at frequent and regular intervals, until the desired percentages of aluminium or silicon contained in the alloy have been secured. This percentage can be regulated entirely at will up to about 70 per cent. of reduced metal. No external heat is used, and the process is absolutely continuous at the will of the operatives, which are special features of the Heroult system. The passage of the electric current through the bath serves not only to keep the copper in a fluid state and to melt the ore, but also electrolyses and decomposes the latter. It is a point of careful regulation in the Heroult processes to maintain only sufficient heat to keep the bath fluid, since any further expenditure is not only useless but lessens the output. The oxygen from the reduced metal combining with the carbon of which the anode is composed is burnt with the production of carbonic oxide gas, which escapes from the crucible around the sides of the anode and at the feed hole. The product is withdrawn at intervals by tapping the bottom of the crucible as in ordinary smelting. Each time the metal is tapped a sample is carefully preserved for accurate analysis, to determine the percentage of contained aluminium.

From a metallurgical point of view, the amount of labour required to operate this process is astonishingly small. The metal produced in the Heroult furnace is sold generally in ingot form, just as it is tapped, without remelting for or being subjected to any purifying manipulation. It is always, however, very pure, sometimes dropping as low as ninety-eight and one-half, but generally running over ninety-nine per cent. of absolute purity. This is largely due to the great care exercised in selecting raw materials. In making bronzes the best Lake Superior copper is used, while the oxide from which the aluminium is reduced is an artificial product manufactured in Prussia. The number of materials from which aluminium may be reduced by these processes is very large, but the strong influence exerted upon this metal by impurities reduces those ores commercially available in this country to corundum and beauxite, both of which are largely used in making low grade metal for treating iron and steel. Kryolith—natural or artificial—is another mineral that plays an important part in the commercial production of pure aluminium, since it is the best flux for alumina, the ore from which the metal is generally reduced. There is to a certain extent a diversity of opinion in regard to the value and properties of aluminium, which is partly the natural sequence to the illusions and exaggerated opinion concerning its commercial and practical value resulting from the romantic descriptions, speculations, and suggestions, with which our scientific and trade literature have been filled ever since Deville's researches were published, and partly the result of impurities in the metal as ordinarily produced. For 35 years after Deville first produced it, aluminium, though much talked of, was but little seen outside of laboratories and lecture rooms, except as we find it on the French and English markets, manufactured into ornamental shapes. It is only since 1886 that it has been manufactured in sufficient quantities and at sufficiently low prices to permit practical metal workers to test its properties on an adequate scale. The very unusual qualities which give it merit, and the great depreciation it undergoes when only slightly contaminated with foreign impurities, such as iron and silicon, together with the further fact that it has only been recently commercially produced of 99 per cent. purity, have had a tendency to prejudice this metal in the eyes of practical people. From this depression it will slowly recover as they secure pure metal. In fact, this very condition was foreseen by Deville, who very early pointed out that those handling aluminium and its alloys would be disappointed at the poor results they obtained where they used metal containing more than 1 per cent of impurity.

Pure aluminium has a beautiful white colour, slightly tinged with blue. It is somewhat fibrous in structure, and bends considerably before breaking. If the metal contains more than 1 per cent. of impurity it becomes brittle, and has a crystalline structure. When pure, it is soft enough to be easily cut with a knife, while the addition of a few per cent. of impurities makes it exceedingly hard. It melts at a slightly lower temperature than silver, and has a specific gravity of 2·6. Taking aluminium at 1·0, the following table (from Deville) will be of interest, as showing the comparative weights of the different metals.

Platinum	8·6
Gold	7·7
Lead	4·8
Mercury	4·2
Copper	3·6
Iron	2·9
Tin	2·8
Zinc	2·8
Aluminium	1·0

The pure metal takes a beautiful polish, uniting with oxygen slowly and with great difficulty, even at a red heat; and when, from long exposure, it finally acquires a very thin coating of oxide, it is not perceptibly tarnished. This coating of oxide protects it from further atmospheric or other baneful influences. It is well known that pure aluminium can be drawn out into the finest wire or into tubes; rolled into plates, stamped into medals (similar to those distributed at the recent Electric Light Convention), beaten into the finest foil, &c. It has an elasticity similar to that of silver, and a tensile strength of about 26,800 lbs. per square inch. The addition of 6 per cent. of copper, however, increases the tensile strength to that of wrought-iron, and a slight percentage of silicon raises its strength to 90,000, though at the expense of other qualities.

The compounds of aluminium formed by the addition of copper, brass or iron, are unquestionably the most commercially important of the aluminium alloys. Aluminium combines with copper in all proportions, but its alloys are as easily influenced by impurities as is the pure metal. It is an important fact worth noting that, when alloys are made by mechanically mixing aluminium and copper, iron, &c., the product must be remelted a number of times to secure any uniformity in the texture of the alloy. The finest alloys by far are those made by uniting the aluminium to the basic metal in atomic proportions, as it is reduced, as in the Heroult process, the uniformity of whose alloys is remarkable. Probably the most useful compound of aluminium and copper is what is known as 10 per cent. bronze, containing 10 per cent. aluminium and 90 per cent. of copper. This alloy is an almost perfect imitation of gold in colour, and is susceptible of taking and retaining a most beautiful polish. It can be rolled, or drawn, or cast very readily; but in casting, the bronze shrinks considerably, and care must be taken to have the feeders amply large. The tensile strength of this bronze is enormous, and the following table from "Trautwine Engineer's Pocket Book" shows it in comparison with other metals:—

	Tensile Strength.
Cast brass	23,000
Annealed brass wire	49,000
Cast copper	24,000
Copper bolts	33,000
Annealed copper wire	32,000
Gun bronze of copper and tin (cast)...	39,000
Cast iron gun metal, U.S. Ordnance	30,000
Average American cast iron	16,000
Good wrought iron	50,000
Best American wrought iron, exceptional	76,000
Iron wires, rope...	88,000
Malleable iron castings	48,000
Steel plates (rolled)	81,000
Cast steel, average Bessemer ingots	63,000
Aluminium bronze, in castings, over...	100,000
Aluminium bronze "special" in castings up to ...	130,000

DYNAMOS.

The following discussion took place on Mr. Blackburn's paper, which we published in the Review for January 30th and February 6th:—

Mr. G. H. Firth asked the reason of the variation in the working of the dynamo, and why the lights should be better on one day than another? In some cases, he said, the commutator required turning up often, owing to the wearing of the brushes; under such circumstances was it desirable to have new brushes?

Mr. John Bartlam mentioned that a dynamo which was under his charge did not work at a high speed, and yet as far as heating was concerned, they never experienced any trouble with it. This seemed to be at variance with the assertion of Mr. Blackburn, "that dynamos were not effective unless worked at high speeds."

Mr. R. S. Holland said he had had considerable experience in the working of dynamos, one of which had been in use for the past five years without having the commutator turned up, or any new brushes. He quite concurred with Mr. Firth that the state of the weather had an effect on the dynamo. The great point, he thought, was to keep the dynamo cool, and it appeared to him that the application of a fan, with the view of getting a current of air round the dynamo, would be advantageous.

Mr. T. Stevens remarked that they had a dynamo which had been running 25 ampères, and that the commutator had been turned up several times during the last three or four months. He should like Mr. Blackburn to tell them if it were necessary, when the current was very high, to put on two machines or more, in place of reducing the number of circuits at such a small load?

Mr. Giles said that like those who had been called upon before him, he had very little to add to Mr. Blackburn's very complete paper. There was, however, one point in the paper to which he would like to draw the attention of the members, viz., that in one place Mr. Blackburn said: "The electricity may be regarded as lying dormant in the system, until set in motion by the pressure generated in the revolving armature, when it makes its presence felt by giving rise to what we call an electric current." He (Mr. Giles) questioned whether electricity could be regarded as lying dormant in the system. He preferred to regard electricity as a form of energy. If so, it must be either kinetic or potential. But if kinetic it could not lie dormant in the system, and if potential, whence did it originate? Again, if not a form of energy, the question arises, what becomes of the energy transmitted by the belt to the dynamo? Of course even if admitted to be a form of energy, we are still confronted with the question, what is the nature of this particular form of energy? and this no one has yet been able to answer.

Mr. Anderton observed that there was one point in connection with dynamos in which he was interested, namely, the lateral motion which was occasionally given to the spindle. In the newer forms of dynamos that seemed to be discontinued, and he should like Mr. Blackburn to explain the reason for it, because to his mind it was a good idea. He thought it would make the commutator wear more evenly, and avoid any grooving, on account of the difference in the degree of hardness which might be in the brushes.

Mr. E. Marshall asked which was the best form of brush, the one composed of wires or that of copper plates; his experience being that the latter were the most effective.

Mr. Thomas Settle desired to know which was the best method of driving a dynamo, namely, by coupling the engine direct to the armature shaft or by rope or belts.

Mr. E. Lowe asked if the circuit, in order to avoid magnetic pull, instead of being constructed with single circuit, might be made in form so that the pull described by Mr. Blackburn will not tend to lift or lower the armature.

Mr. W. P. James Fawcus (in a written communication) said: I have read with great interest Mr. Blackburn's most able paper, and should like to ask him if he could give a little further information on one or two points. It has often been brought to my notice that when a machine has been sparking persistently, the substitution of another kind of brush has either entirely cured the evil or considerably mitigated it, this has been more noticeably the case in the substitution of gauze or thin plate brushes for those made of wire. Has the flexibility of the two former anything to do with it? It seems to me that with a very stiff brush any vibration of the machine may cause the brush to jar off the commutator and so cause sparking unless an excessive pressure is used to keep contact, in which case there is a danger of the commutator being unduly ground away. Also, what quality of copper, soft or hard, is the most suitable for the purpose. There seems to be a general opinion that the Manchester type of dynamo is more liable to sparking than the Edison-Hopkinson. What is the reason of this? The Edison-Hopkinson type of machine is generally admitted to be the most efficient at present in existence—I understand a commercial efficiency of 95 per cent. has been reached. Would Mr. Blackburn say how this superiority is to be accounted for. Although Mr. Blackburn only alluded to continuous current dynamos in his paper, I think it would be interesting to know why alternating current machines are not in more general use in large buildings, such as mills. Their greater simplicity in having no commutator would seem to render them particularly suitable in cases where no accumulators had to be charged. Also it would seem that the first cost and cost of maintenance of such machines should be less.

Mr. Blackburn, in replying to the remarks made by Mr. Fawcus and several other speakers respecting brushes, said there is good reason for supposing that contact is improved and sparking diminished by a flexible brush which follows any irregularity of surface in the commutator, and is less easily lifted by vibration. The copper should be moderately hard to prevent permanent set under the stress of the brush-holder spring. If wear of the commutator is distinctly due to brushes being too hard and creating too much friction between the surfaces, more flexible ones should be tried, that is those made of thinner wires or plates, but it is still more important to see that they are set diametrically opposite to one another and with proper lead, and that the right amount of pressure is given, and that the attendant is careful and keeps the holders clean so that they work freely and do not stick. In reply to the question from Mr. Fawcus as to the reason for the superiority of the Edison-Hopkinson dynamo in respect to sparking, he had pointed out that a drum armature having least self-induction is freer from this tendency than a ring armature, and, moreover, in the Edison-Hopkinson machine the mass of iron is greater, which contributes to the same end by reducing the number of convolutions in the armature. As regards the merits of alternating current dynamos, their efficiency is decidedly lower than that of continuous current dynamos, and the necessity for an exciter makes them more complex and expensive for small and medium sizes; and considering the small amount of care which a good continuous current dynamo requires, there does not seem to be any inducement to use them. In the early days of electric lighting they were a good deal used, because there was no good continuous current machine in the market, but as soon as these were perfected they rapidly superseded the alternating machines. Reference has been made by Mr. G. H. Firth and Mr. Holland to atmospheric changes affecting the working. Moisture is the greatest enemy we have to contend with in electric lighting, but in any substantially erected installation, where the insulation is good, the state of the atmosphere cannot make any material difference, though if there is much moisture either about the fittings or machine there will be leakage until it is dissipated; this, unless the insulation is very defective, will soon occur after commencing to work. In reply to Mr. Bartlam, it is necessary to distinguish between efficiency in the sense of economy of power and that of satisfactory mechanical performance, the latter alone limits the speed. If the machine to which he refers, although working at a low speed, is well proportioned and massive for its output, it may return a large percentage of the power applied, although if it had been wound with fewer convolutions on the armature and run at a higher speed, a still better return would have been obtained. As regards the application of a fan, as advocated by Mr. Holland, the fan may cool the armature so as to enable it to carry more current up to the point at which armature reaction causes sparking to commence. The heating will be due either to eddy currents or to the section of copper being too small. In either case, notwithstanding the use of the fan, a loss will still be going on, so that it is better to construct the machine with laminated armature conductors and section of copper large enough to render the use of the fan unnecessary, but where the evil exists the use of a fan will certainly mitigate it. If he rightly understood Mr. Stevens's question, he finds his commutator wears even when the machine is lightly loaded. He would do well to have it thoroughly examined, as either it is radically bad, out of repair, or the brushes are not properly applied. Lateral movement of the armature referred to by Mr. Anderton, certainly tends to prevent grooving of the commutator, but without the complexity of special gear it is difficult to control, and may cause percussion between the collar and bearing. In a good machine with suitable brushes the grooving is so slight, and can be so easily checked by occasionally shifting the brush-holders along the spindle, that lateral movement is unnecessary. Mr. E. Lowe asked if the use of four poles would not neutralise magnetic pull on the armature due to unsymmetrical field. This, or a double circuit, as in the Manchester machine, can be applied to affect it, but there is no special difficulty or disadvantage in placing the armature eccentric to the bore, a sixteenth or eighth of an inch is generally sufficient, and by suitable adjustment it can be made useful to support the weight of the armature, and so relieve the bearings. In reply to Mr. Giles, although the hypothesis of one or more electric fluids in the conductor is no longer tenable, modern conceptions do not permit of electricity being described as energy, any more than matter can be so described. Energy is defined to be capacity for doing work; matter endowed with either kinetic or potential energy can do work, but to have attained this condition it must already have had work done on it. Electricity can do no work until separation has taken place by work being done on it; it cannot therefore be energy. Every advance in our knowledge points more and more to the dielectric and not the conductor as the medium by which the energy is conveyed, and electricity may prove to be only another name for the electro-magnetic ether. The impressed energy producing separation in an open circuit will be in the potential condition, becoming kinetic as soon as the circuit is closed or the impressing force relaxed. To suppose that electricity is transferred along a conductor like water through a pipe would, of course, be incorrect, but figuratively the comparison enables the direction of the flow to be traced, and leads up to the explanation of the relation between pressure current and resistance.

NEW PATENTS—1891.

7,204. "Improvements in electric alarms." W. Kingsland. Dated April 27th.

7,261. "Improvements in and relating to the electro-deposition of metals upon fabrics, plants, animals, and the like." E. Denorus. Dated April 27th.

7,308. "Improvements in musical instruments actuated by electricity." P. E. Singer. Dated April 28th.

7,315. "Improvements in method of and apparatus for electrically supplying hot water for consumption and heating purposes." M. W. Dewey. Dated April 28th. (*Complete.*)

7,333. "Improvements in and relating to dynamo-electric machines." W. P. Thompson. (Communicated by F. Tischendörfer, United States.) Dated April 28th.

7,427. "Improvements in electric time locks." W. W. Horn, (Communicated by M. I. Flowers, J. E. Jones and C. W. Price, United States.) Dated April 29th.

7,433. "A leakage detector or insulation tester, to be employed in the testing of electric lighting conductors and other leads." Sir D. L. Salomons, Bart. Dated April 29th.

7,603. "Yule's electric signalling apparatus for passenger trains." J. S. Yule and C. W. Stewart. Dated May 2nd.

7,614. "Regulating the brilliancy of electric incandescent lights." T. P. Walker. Dated May 2nd.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1890.

771. "Improvements in and connected with telephone systems." W. Oesterreich and W. Genest. Dated 15th January. 8d. By means of the invention the speaking stations are enabled to communicate severally with each other without any intermediary person. 4 claims.

1,068. "Improvements in dynamo or electro-motor conductors." G. B. Luckhoff and E. H. Hungerbuhler. Dated 21st January. 6d. Claims:—1. The use of compound or electro-magnetic conductors consisting of copper wire covered by spiral windings of iron, nickel or cobalt wire, or ribbon, and fixed on the copper wire by solder or an electro-deposited metal. 2. The use of conductors consisting of copper wire covered with iron, nickel or cobalt deposited by electrical means on the said copper wire.

1,306. "Improvements in galvanic dry elements." C. Smith. (A communication from abroad by W. L. F. Hellesen, of Copenhagen.) Dated January 24th. 6d. Consists of two receptacles one within the other, the interior receptacle being made of zinc and provided with ventilating holes. The space between these two receptacles is filled with sawdust or similar substance. The carbon used is hollow, covered on the outside with a depolarising substance, its interior being filled with a substance capable of absorbing a large amount of moisture. Outside the depolarising substance is a doughy or similar substance containing the electrolyte. Above this is a porous layer, such as plaster of Paris, covered over with a very close compact layer, such as pitch, so that the escaping gas must pass through the plaster of Paris layer, thence through the ventilating holes placed opposite this in the zinc receptacle, and finally pass out through air tubes close to the bottom of the outer receptacle. 1 claim.

1,555. "An improved magnetic separator." G. W. Elliott. Dated January 29th. 8d. Claims:—1. In a magnetic separator, a revolving chamber or drum carrying with it electro-magnets on the internal surface, for the purpose of separating materials of different magnetic susceptibilities, the material traversing the revolving drum during its rotation, substantially as described. 2. In such a magnetic separator the arrangement of electro-magnets and distributing contacts to enable the magnets to be demagnetised during a portion of the revolution to release or allow to be brushed off, the attracted magnetic material, for collection in a suitable tray or shoot, substantially as described. 3. The arrangement and general combination of parts of a magnetic separator substantially as described and illustrated.

2,080. "Improvements in devices for unloading, recharging, and reloading electric car storage batteries." J. C. Chamberlain. Dated 10th July, 1889. (Under International Convention.) 11d. Relates to those systems of electric traction in which the current is derived from storage batteries, or accumulators, located upon the car itself, the purpose of the invention being to enable the substitution of charged for exhausted batteries in the most expeditious, economical and effective manner possible. 17 claims.

2,091. "Improvements in secondary batteries and plates or elements therefor." W. P. Thompson. (A communication from abroad by The Gibson Electric Company of Europe, Paris.) Dated February 8th. 8d. Claims:—1. A storage battery, having in combination, a series of superposed plates each furnished with active material, rods passing successively through said plates, washers on the rods interposed between the plates and bearing against the rigid bodies thereof, and means for drawing the plates and washers firmly together upon the rods, substantially as described. 2. In a storage battery a series of superposed plates each furnished with active material and each having one or more recesses at its sides adapted to permit the electrodes of the plates below it to pass upwards, whereby the size of the containing vessel of the battery may be reduced to approximately the same size as the plates. 3. A battery plate consisting of a sheet of metal having perforations, raised rim and recesses at the side, substantially as described and shown on the drawings, and for the purposes specified.

2,153. "Improvements in telephone switchboards." D. Dewar. Dated February 10th. 8d. The inventor arranges the switch lever to oscillate in brackets and act upon hinged pieces of brass or other suitable metal carrying two hard rubber or ebonite discs with beveled edges, and provided with studs of rubber or metal at their backs. These hinged pieces on being separated by the lever assume an angular position with regard to each other and act on springs and connections and lock the key in position until released by the lever being moved in a contrary direction; the said parts are mounted on a detachable block of hard rubber which is attached by means of screws to the main block or piece carrying the springs and connections. By simply removing the said screws and detaching the rubber handles of the levers, the lower block with its attachments can be lowered, the worn parts renewed and the whole replaced without involving any great delay to the operator. 3 claims.

2,172. "A new or improved mechanical switch for completing and breaking the circuit of electric tell-tales for watchmen and the like within the prescribed time." H. Boardman. Dated February 11th. 8d. Consists of a switch fixed at the station the watchmen is required to visit, and adapted to be operated by clockwork arranged to be wound up by the watchman which closes the switch and completes the circuit, but as the clockwork runs down the switch is again opened, thus breaking the circuit and preventing any register being made from the recording station without it is visited whilst the circuit was complete. One or more of these time switches may be fixed in one circuit, each of which it will be necessary for the watchman to visit before going to the recording station to register the visit or visits, and the round must be completed before the time switch or switches has or have run down and broken the circuit. 1 claim.

2,491. "Improvements in casings, beadings, and mouldings for containing, covering, and insulating electric wires for lighting or other purposes." W. Gritten and A. Parmley. Dated February 15th. 8d. The inventors make grooved strips of sufficient length, and preferably rectangular in section of a composition consisting of plaster, cement of any suitable kind, clay, or other substance of the like kind, with which is incorporated what is well-known as silicate cotton or slag wool, fibres of asbestos or the like fibrous incombustible material, non-couducting electricity. 2 claims.

2,503. "Improvements in electric arc lighting," L. Saunderson. Dated February 15th. 8d. Relates to a method of electric arc lighting in which hydro-carbon vapour was introduced into the arc through one or both of the carbons made hollow for that purpose. In order to prevent the hydro-carbon from being absorbed by the porous carbon electrode and saturating the same, and so to escape in vapour before it reaches the arc, the inventor lines the interior passage in the electrode with an enamel consisting of hard pitch or bitumen dissolved in a solvent. This enamel he applies with a brush, and allows it to harden. In the same way, he coats the end of the electrode where the same is inserted into box, and the exterior surface of the carbon may be similarly coated if desired. Thus the hydro-carbon liquid is kept from contact with the porous surface of the electrode. In order to prevent the passage of the electric current through the heated carbon of the electrode from decomposing the hydro-carbon and producing a deposit of carbon tending to fill up and stop the hole through the electrode, he introduces into the hole above the wick (which he inserts into the lower part of the hole) filaments or pieces of asbestos, or other non-conductor of electricity, which prevent the deposit of carbon, and keep the hole open. 4 claims.

2,653. "Improvements in electric meters." S. Z. de Ferranti. Dated February 18th. 8d. Claims:—1. Suspending or partially suspending the armature spindles of electric meters by magnets. 2. An electric meter for recording the passage of alternating currents in which the armature spindle is suspended, or partially suspended, by an electro-magnet or magnets energised by the alternating current. 3. An electric meter in which the armature spindle is suspended, or partially suspended, by a magnet and in which the suspending magnet serves also to produce Foucault currents in a metallic disc carried by the spindle. 4. The improvements in electric meters substantially as described.

2,654. "Improvements in the manufacture of electric cables." J. E. Kingsbury. (A communication from abroad by the Western Electric Company of Chicago.) Dated February 18th. 8d. Consists in placing the core of insulated conductors deprived of moisture within the pipe and then forcing insulating filling, such for example as melted paraffin into both ends of the pipe thereby compressing the gas and air between the said fillings—gas (carbonic-dioxide) under pressure is first forced into the pipe, and then insulating filling material under a greater pressure is forced into the ends of the pipe. 4 claims.

2,759. "Improvements in the lighting of railway trains by electricity." I. A. Timmis. Dated February 20th. 8d. The inventor puts a large battery in a guard's van or other suitable vehicle and light the train or any convenient number of vehicles from it by means of main lighting lamps and suitable leads and couplers and switches. This enables him to use lamps of high voltage and strong candle-power. 2 claims.

8,853. "Improved combined brake and circuit making and breaking device for use with electric motors." A. Piat. Dated 7th June. 8d. Comprises an operating lever adapted to be electrically connected with the electro-motor to be controlled, and provided with brake blocks adapted to act against the flywheel of the said electro-motor, which latter is electrically connected with a dynamo or other generator by means of electrical conductors attached to terminals carried by fixed insulated contact pieces, and by means of electrical conductors connected to contact fingers carried by the operating lever. 1 claim.

8,933. "Improvements in the method of and apparatus for depositing metals by electro-deposition." G. H. Felt. Dated 10th June. 8d. Has particular reference to the electro-deposition of the metal known as aluminium. Consists, broadly, in adding to the liquid, which surrounds the cathode of a galvanic battery, clay, as free as possible from impurities, preferably in conjunction with a weak solution of nitrate of mercury. 15 claims.

10,445. "An improved electric prod pole." J. P. Bayly. (A communication from abroad by J. Burton, E. Roach, R. MacNair, W. P. MacNair, and C. Lanning, all of America.) Dated 5th July. 8d. This invention relates to certain improvements in prod poles—such as are used at ranches, stock yards and the like, to excite cattle to cause them to move forward when loading a car with them; and it consists in providing the prod poles with contact points respectively connected through the medium of insulated wires with the positive and negative poles of an electric apparatus in such manner that when the poles are at rest the electric circuit will be broken, and when in use in contact with an animal the circuit will, through the medium of the animal, be connected and give an electric shock to the animal. 4 claims.

11,288. "Improvements in armatures for dynamos." J. Vinicombe. Dated July 19th. 6d. Claim:—The general arrangement and method or means of forming armatures for dynamos of the "tooth ring" form, and of providing, as in combination therewith, a form of "spider" and series of air propellers or fans of opposite pitch, at each outer end of the armature, to create a partial vacuum within or inside the ring spaces, so as to induce fresh and constant currents of air to circulate through the laminated spaces and around the whole series of rings, substantially for the particular purpose as described, set forth and illustrated.

14,260. "Improvements in electric or magnetic carrier systems, otherwise known as Port-electrics." H. J. Haddan. (A communication from abroad by J. T. Williams, of America.) Dated September 10th. 8d. Consists, among other things, of improvements whereby the electro-magnet or magnets by means whereof the travelling car or carriage has motion imparted to it are mounted upon and travel with the car or carriage. 7 claims.

14,613. "Electric motor car." W. Robinson. Dated September 16th. 8d. The object of the invention is to construct a motor car having axles adapted to take a radial position on curves, to adapt and combine the electric motors with the radiating apparatus in a simple and practical manner, whereby cars with a long wheel base may run around very sharp curves with the greatest ease, with economy of power, and without danger of leaving the track, and to secure an elastic, easy and comparatively noiseless operation of the whole apparatus. 26 claims.

14,634. "Improved apparatus for electric light signalling." E. F. Inglefield. Dated September 16th. 6d. The inventor employs several lamps, preferably six in number, each being of such construction as to show lights of three different colours, for instance, white, green and red, they being employed so that no lamp should show more than one colour at any one time. 2 claims.

15,084. "Improvements in electric railway conduits with tubular conductors." C. J. Van Depoele. Dated May 22nd. (Under International Convention.) 8d. The inventor forms each main supply conductor as a continuous metallic tube, which may be of any desirable metal although the cheapest forms, such as wrought iron gas pipe, will answer for this purpose. The tubular conductor is to be well insulated upon its outside as by a coating of a heavy bituminous substance having high insulating properties, together with a strong fabric. The tubular conductor is carried upon insulating supports within the best known form of slotted sub-surface conduit, the conductor being then doubly protected. The current is collected from the interior surface of the tubular conductor by contact-making devices in the form of metallic plungers carried by insulating sockets detachably secured in the conductor and readily removable for replacement or examination. 6 claims.

16,889. "Improvements in electro-motors." Rankin Kennedy. Dated October 23rd. 8d. The motor consists of two parts. Firstly, a motor of any of the well-known types of continuous current motors commonly in use, having a laminated field magnet and the commutator removed, leaving the ends of each armature coil or section disconnected from each other, and so that they may readily be connected to sections of wire coils on the second part of the electro-motor. This second part of the electro-motor is a converter having a primary and secondary winding, and an almost perfectly closed magnetic circuit laminated throughout. That part of the magnetic circuit carrying the primary winding is fixed, and of the form of a dynamo field magnet, and that part of the magnetic circuit carrying the secondary winding is mounted on the same shaft with the armature of the motor part, and the secondary winding is in as many sections as there are sections in the motor armature coils, the sections of the one being connected to corresponding sections of the other, as hereinafter described. 4 claims.

REVIEWS.

Screws and Screw Making, with a Chapter on the Milling Machine. Colchester: The Britannia Company.

This treatise, though actually no doubt written for the purpose of advertising the wares of the Britannia Company, is a very complete work, dealing with screw-making in all its branches, embracing most recent methods, and containing the reports which originated modern standard screw-threads. As stated in the preface, it is no doubt the largest volume devoted to screws and screw-making entirely, that has yet been brought out. In the opening chapter the general history of the development of the various systems of screws is given, and the necessity of some system being adopted is pointed out by illustrations of the bad effect of screws which fit incorrectly. The history of accurate screw-making dates back just half a century, and, as is well known, is due to Sir Joseph Whitworth, who first introduced to notice his system in 1841. In 1881 the British Association determined a gauge for the various small screws used for telegraphic and electrical apparatus, in clockwork, &c., on the basis tabulated by Prof. Thury. How far this system has now come to be accepted it is difficult to say, but doubtless it will gradually lead to the extinction of other systems; it is adopted by the British Postal Telegraph Department. Following the chapters on the various systems of screws, we have a chapter on chasing screws by hand, and then fully illustrated descriptions of screw-plates, dies and taps. The more important part of the book, viz., that dealing with cutting screws in the lathe is next met with, this part savouring very much of the advertising character, though at the same time it gives much valuable information. Tables of change wheels are then given, and, finally, a chapter on the milling machine completes what is undoubtedly a very useful treatise.

Coal, and what we get from it. By Raphael Meldola, F.R.S. The "Romance of Science" series. London: Society for Promoting Christian Knowledge.

It has been said that gas is now one of the least valuable products that can be obtained from coal, and that were this illuminant supplied free of charge by the gas companies they would still be able to pay fair dividends from the valuable bye-products resulting from the distillation. Anyone who has not considered the subject would be surprised to find what a mine of wealth is contained in coal tar, and what an entertaining lecture can be made in describing the same. The old woman also who found comfort in "that blessed word, Mesopotamia," would doubtless be soothed by the numerous many syllable words which express the organic compounds from the tar products. The author of the book has certainly done his work well. An addendum, which he gives at the conclusion, is interesting, and is as follows:—

"With reference to the consumption of coal in London, it appears from the Report of a Committee of the Corporation of London, issued at the end of 1890, that the present rate of consumption in the Metropolis is 9,709,000 tons per annum. This corresponds to 26,600 tons per diem. It has been proved by experiment, that when coal is burnt in an open grate, from one to three per cent. of the coal escapes in the form of unburnt solid particles, or 'soot,' and about 10 per cent. is lost in the form of volatile compounds of carbon. It has been estimated that the total amount of coal annually wasted by imperfect combustion in this country is 45,000,000 tons corresponding to about £12,000,000, taking the value of coal at the pit's mouth. Taking the unconsumed solid particles at the very lowest estimate of 1 per cent., it will be seen that, in London alone, we are sending forth carbonaceous and tarry matter into the atmosphere at the rate of about 266 tons daily; and volatile carbon compounds at the daily rate of 2,660 tons. At the price of coal in London this means that, in solid combustibles alone, we are absolutely squandering about £10,000 annually, to say nothing of the damage caused by the presence of this sooty pall. Such facts as these require no comment: they speak for themselves in sombre gloom, and in the sickliness of our town vegetation—they give a new meaning to the term 'in darkest London,' and they plead eloquently for science and legislation to show us 'the way out.'"

Colour Measurement and Mixture. By Capt. W. De W. Abney, F.R.S. London: Society for Promoting Christian Knowledge.

There are few men more capable than Captain Abney of dealing with the subject treated of in this book, and in securing him as the author of one of the "Romance of Science" series the S.P.C.K. have done well. It may be questioned, however, whether some of the writing is not too advanced for a book of the kind, or rather whether the explanations given are sufficiently diffuse; thus, to take a simple case, the writer speaks of a "collimating" lens, a word which will be meaningless to nine out of ten of the readers of the book; the latter, in fact, requires supplementing by a modern elementary treatise on light, its value would then be greatly increased.

CORRESPONDENCE.

It Was a Dream.

It may seem unlikely—if not actually impossible—yet, nevertheless 'tis true, that I fell asleep the other evening whilst trying to read Dr. Fleming's last paper before the Institute of Electrical Engineers, and I dreamed a wondrous dream.

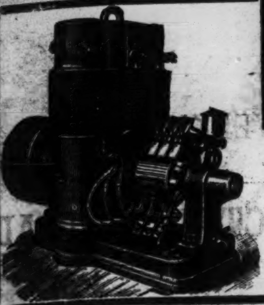
From an exhibition of pure science, I wandered off in imagination and the future to an Exhibition of applied knowledge, held in some large glass building or other. The vision began with a full dress rehearsal of the opening ceremony, and with a feeling of satisfaction, I turned from the reception room and followed the crowd to a large area, where, at 5 p.m. exactly, the growing darkness of a late autumn evening was to be instantaneously exchanged for the brilliant outpourings of numberless arc lamps and projectors. Mounting a ladder in lieu of rostrum, the ASSISTANT ENGINEER (caps., please, Mr. Printer) briefly addressed the assembly as follows:—"Ladies and gentlemen—When hi turn the 'andle, I shall switch hon the current, and the lamps will light."

And he turned the "'andle," but the current didn't switch "hon," nor yet would the lamps light. The air turned blue, but not with suppressed or lengthy arcs. I walked away in disgust, and whilst traversing a dark staircase, fell down, down, down, an interminable distance, until the bottom hit me with a thud: and I woke on the floor of my own room.

After that I carefully read Dr. Fleming's paper once more, but was in no wise consoled, for he gives no equation which could solve out x, the unknown quantity of cheek possessed by certain individuals who pose as electrical engineers, or electricians.

C. P.

[After such terrible experiences we can scarcely imagine our correspondent warbling, even in his slumber, "Let me dream again;" still, upon those who are not quick at perception, the letter of C. P. may produce the same results as he himself experienced.—Eds. Elec. Rev].



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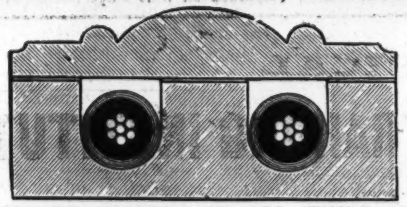

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It is, perhaps, now almost superfluous to point out the necessity for only the best of everything being used in electric light installations. Still, there are some firms who, either from a mistaken notion of economy or for want of satisfying themselves as to what is the best, continue to use antique types of switches and cut-outs which were considered good enough five years since but which are now giving place generally to improved types. As an instance of one important improvement in these incidentals to an installation we would call the attention of those of our friends who have not been using them to our Patent Safety Cut-Out.

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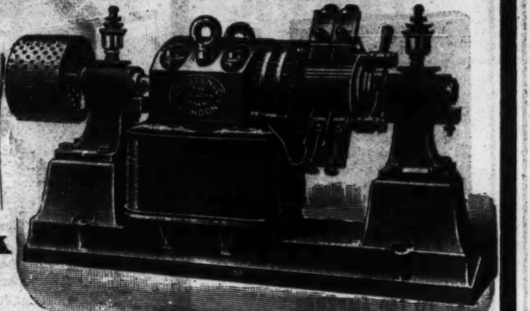

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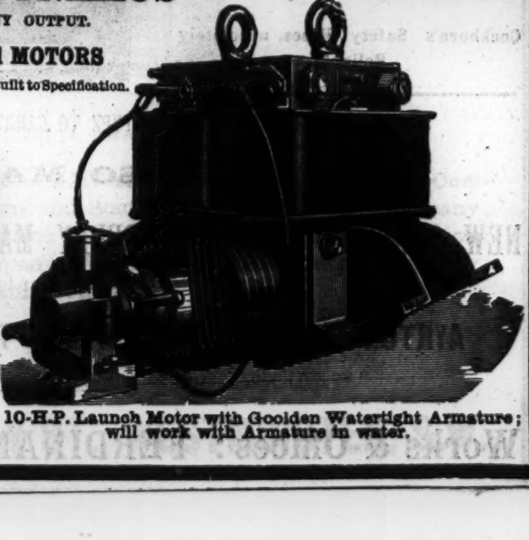

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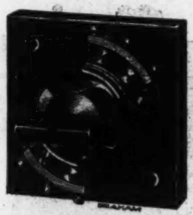

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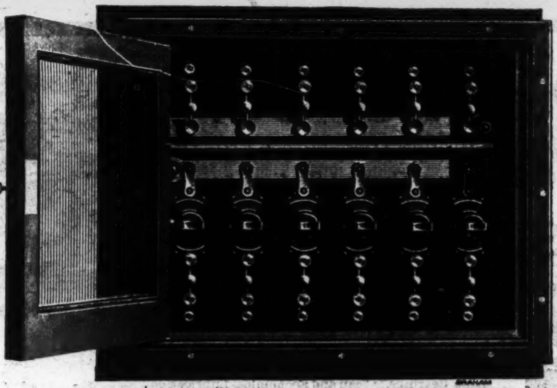

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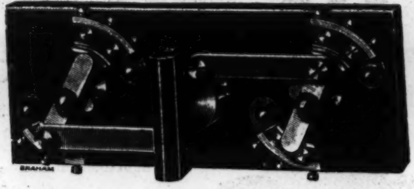

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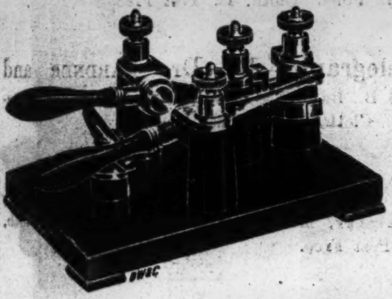

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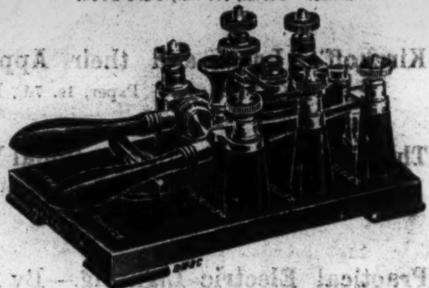

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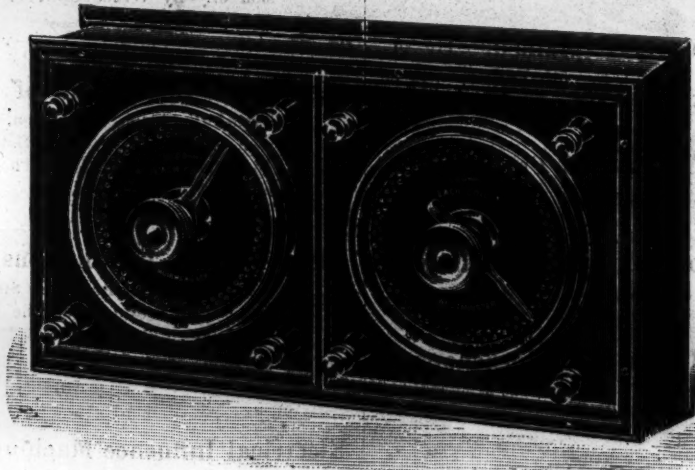

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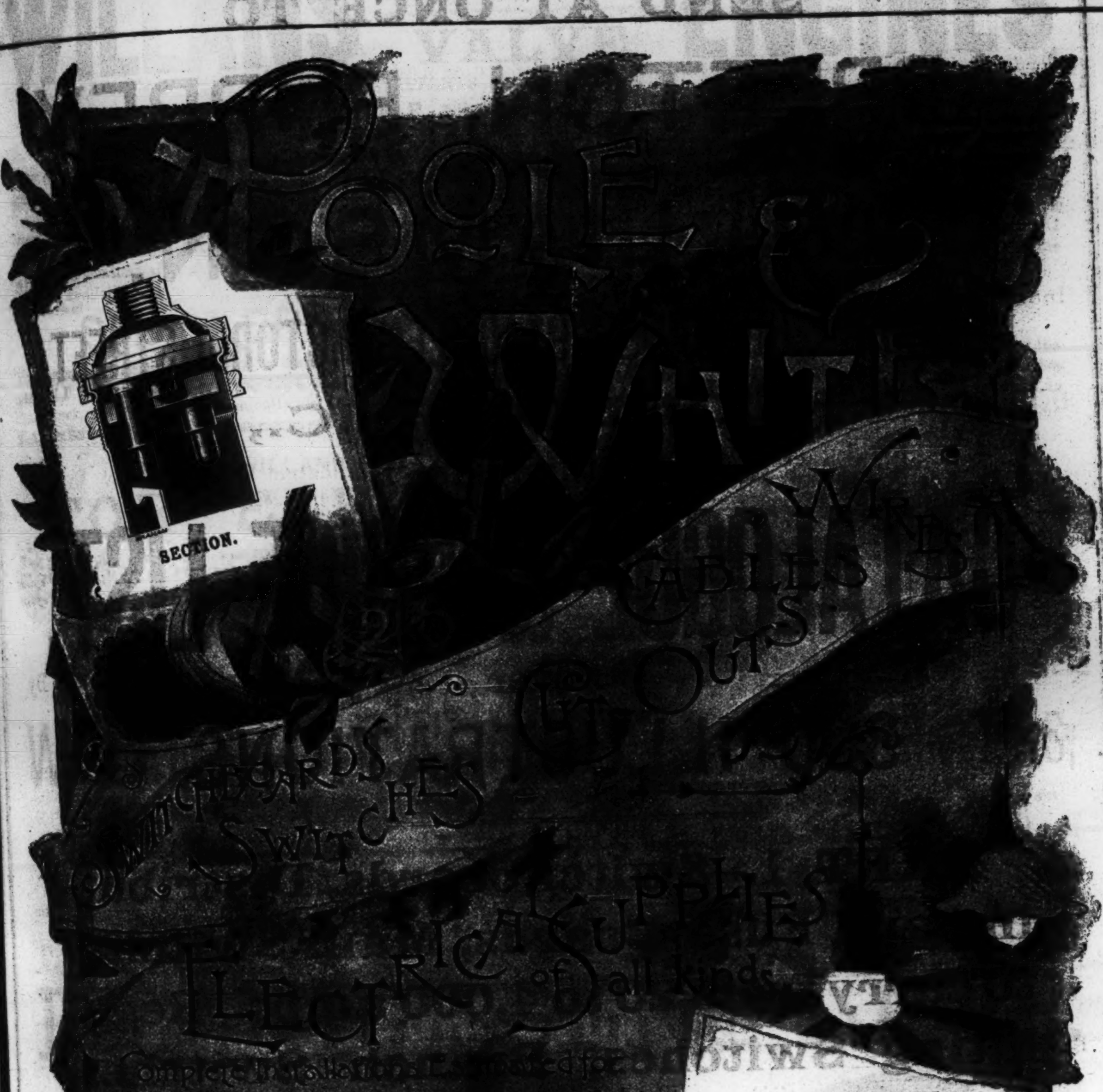

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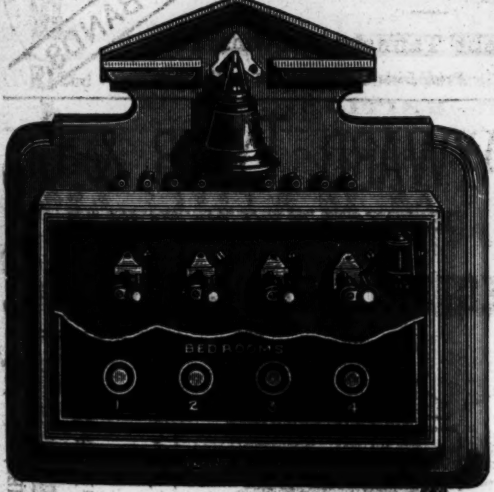

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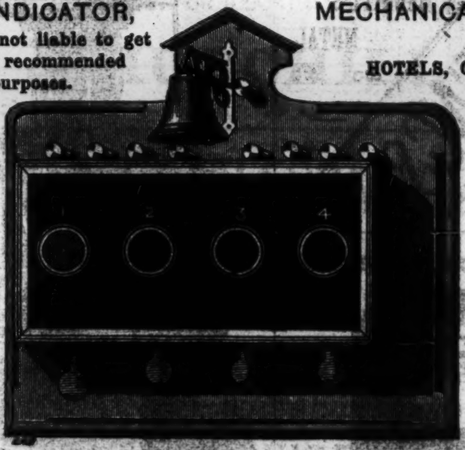

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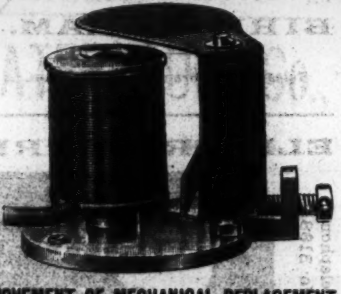

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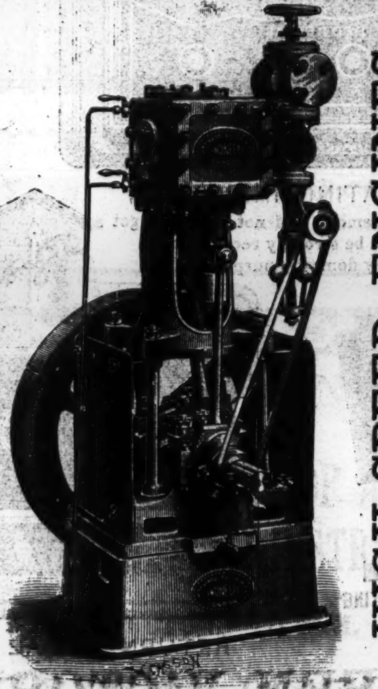

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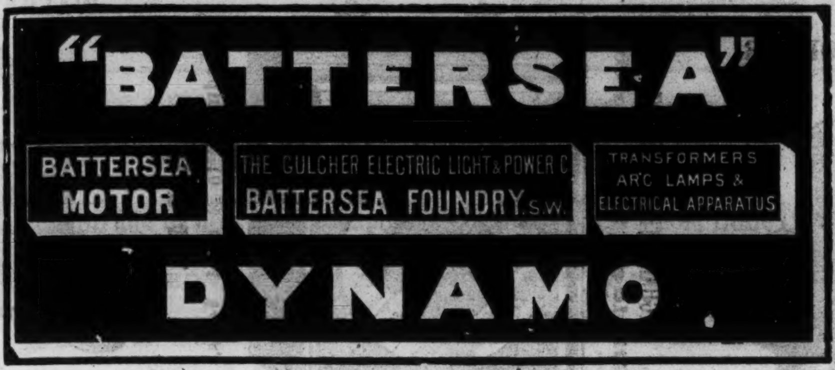

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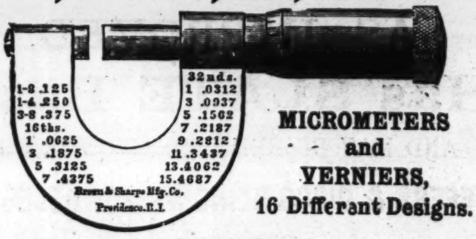

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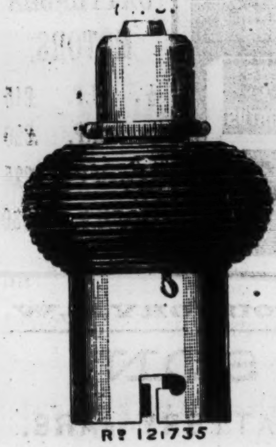

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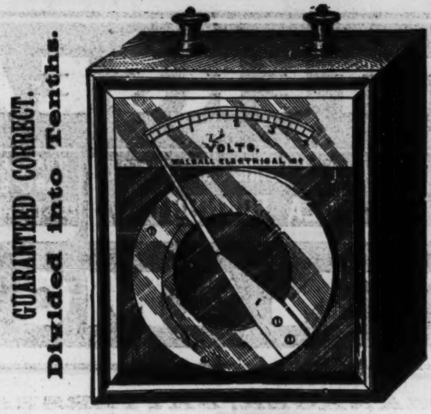

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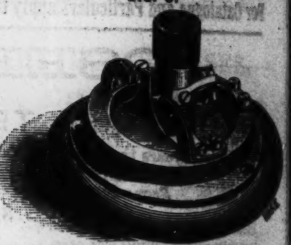

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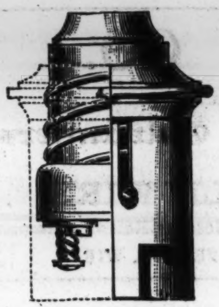

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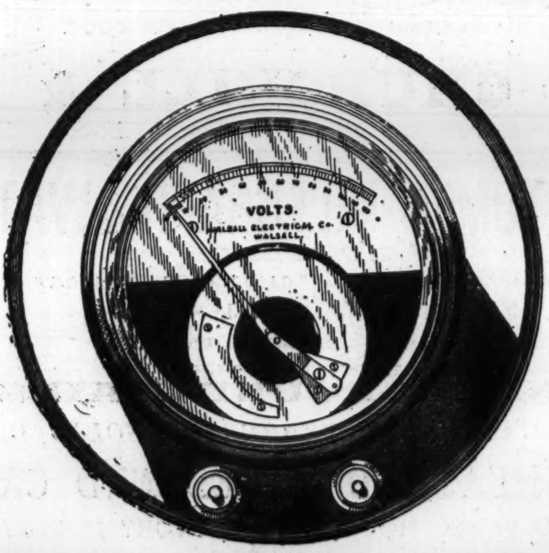

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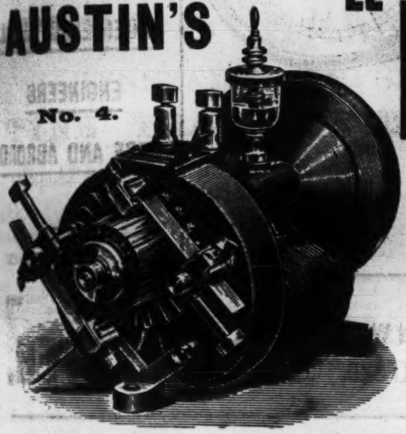

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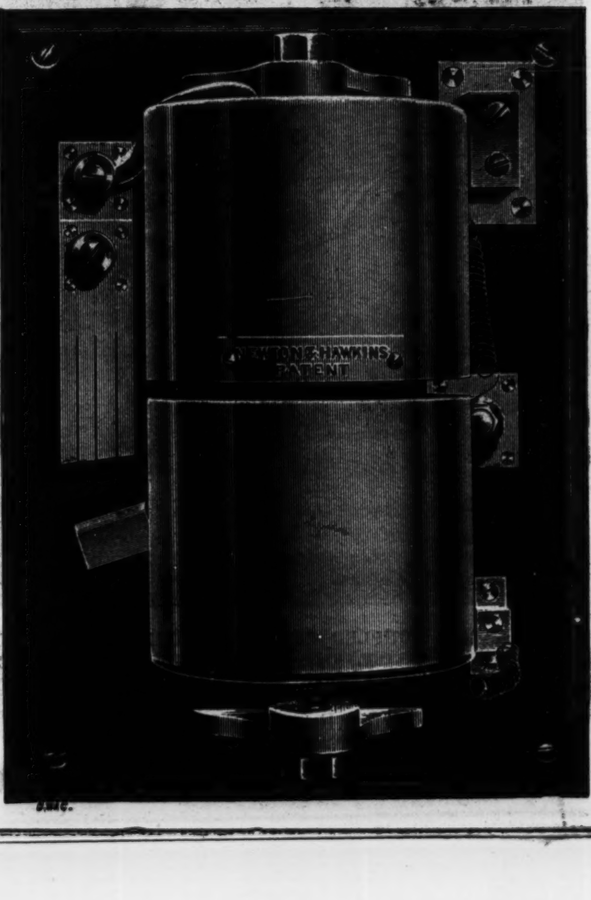

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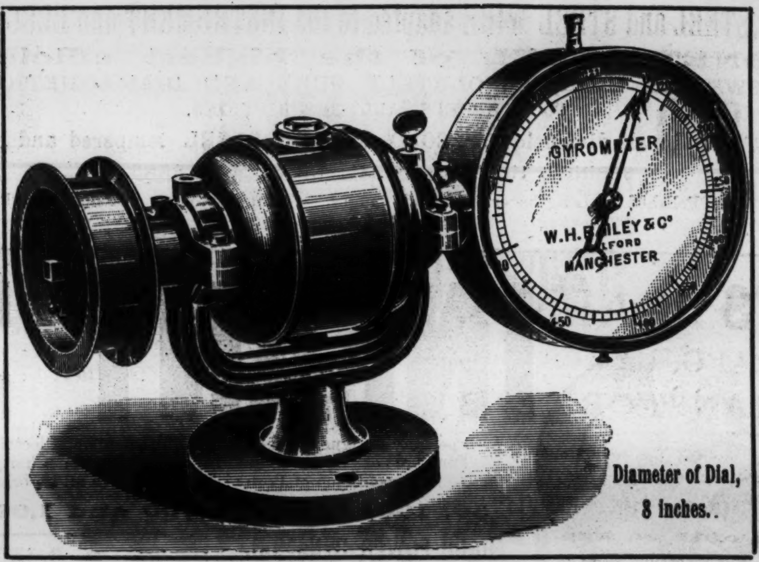

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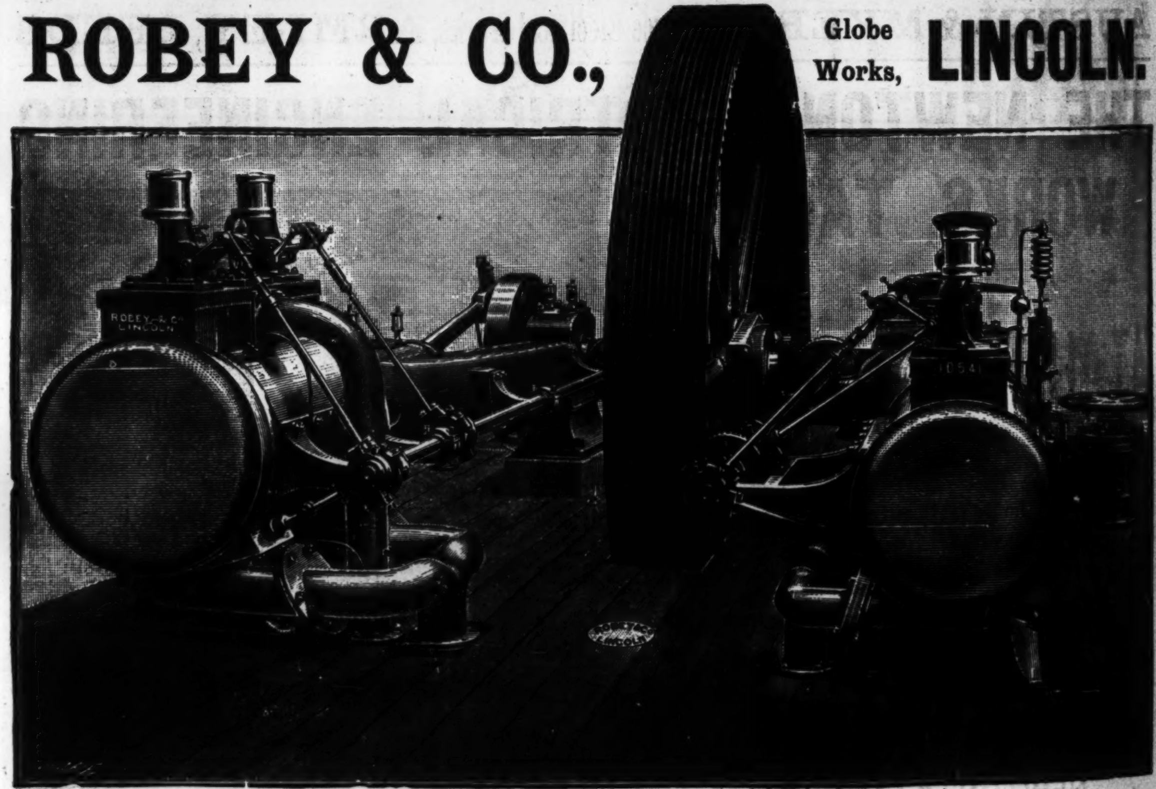

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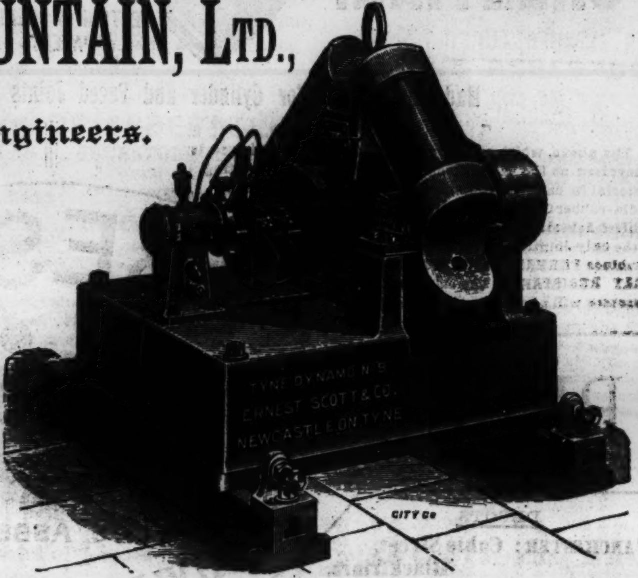

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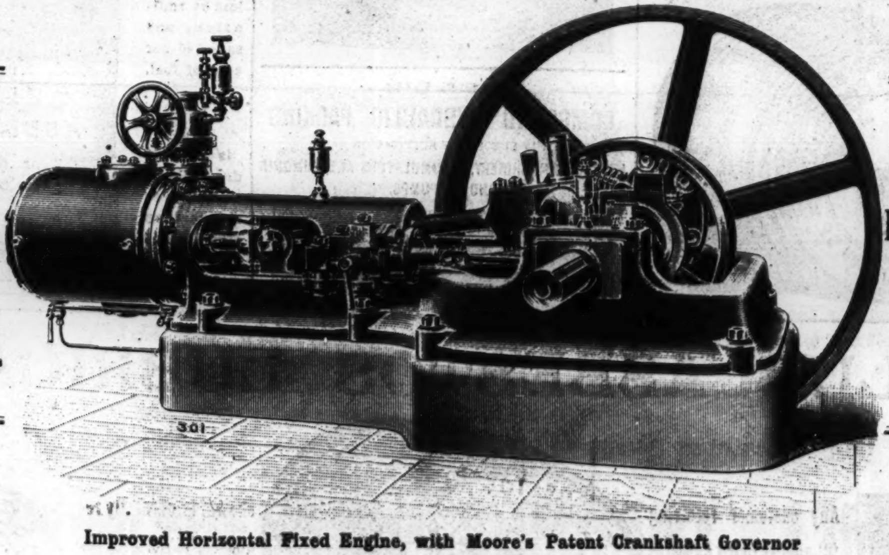

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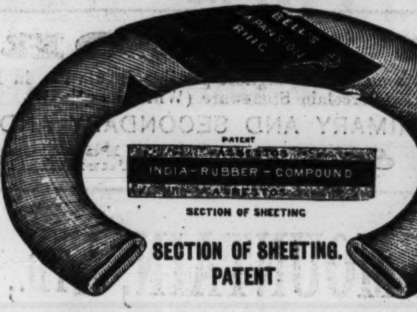

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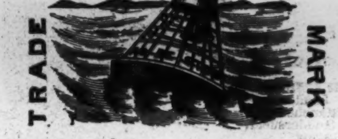

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Any customer receiving Oil sold as Bell's Asbestos Lubricant, & Cask, Drum, or Corks not marked as shown, is earnestly requested to forward us sample and particulars of where obtained.

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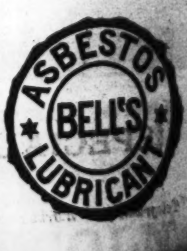

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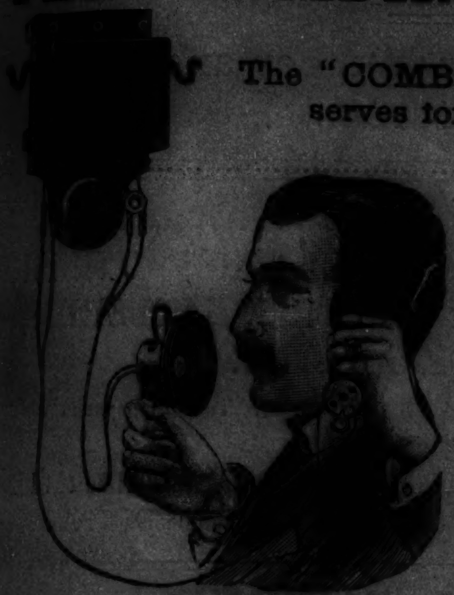

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